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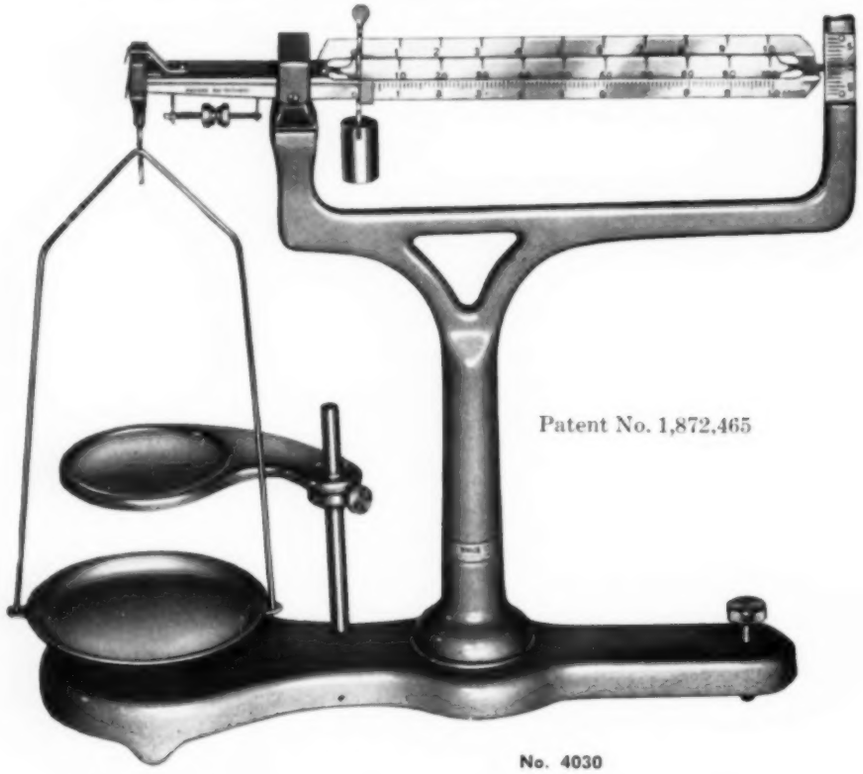

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Slants on Conservation Education
By N. R. Casillo, New Castle High School, New Castle, Pennsylvania.

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By Lydia Bourne Walsh, Department of Biology, Elmira College, Elmira, New York.

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Modern Trends in High School Chemistry
By Sister M. Lawrence, R.S.M., Department of Chemistry, Mount Mercy College, Pittsburgh, Pennsylvania.

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Iodine, Element of Many Uses
By H. J. Cordle, Director, Chilean Iodine Educational Bureau, New York, New York.

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Fluorescent Lamps
By Joseph P. Baker, Westinghouse Electric Company, Pittsburgh, Pennsylvania.

•

A Study of Current Scientific Writing
By Lois Kennedy, Marycrest College, Davenport, Iowa.

The Bell Solar Battery

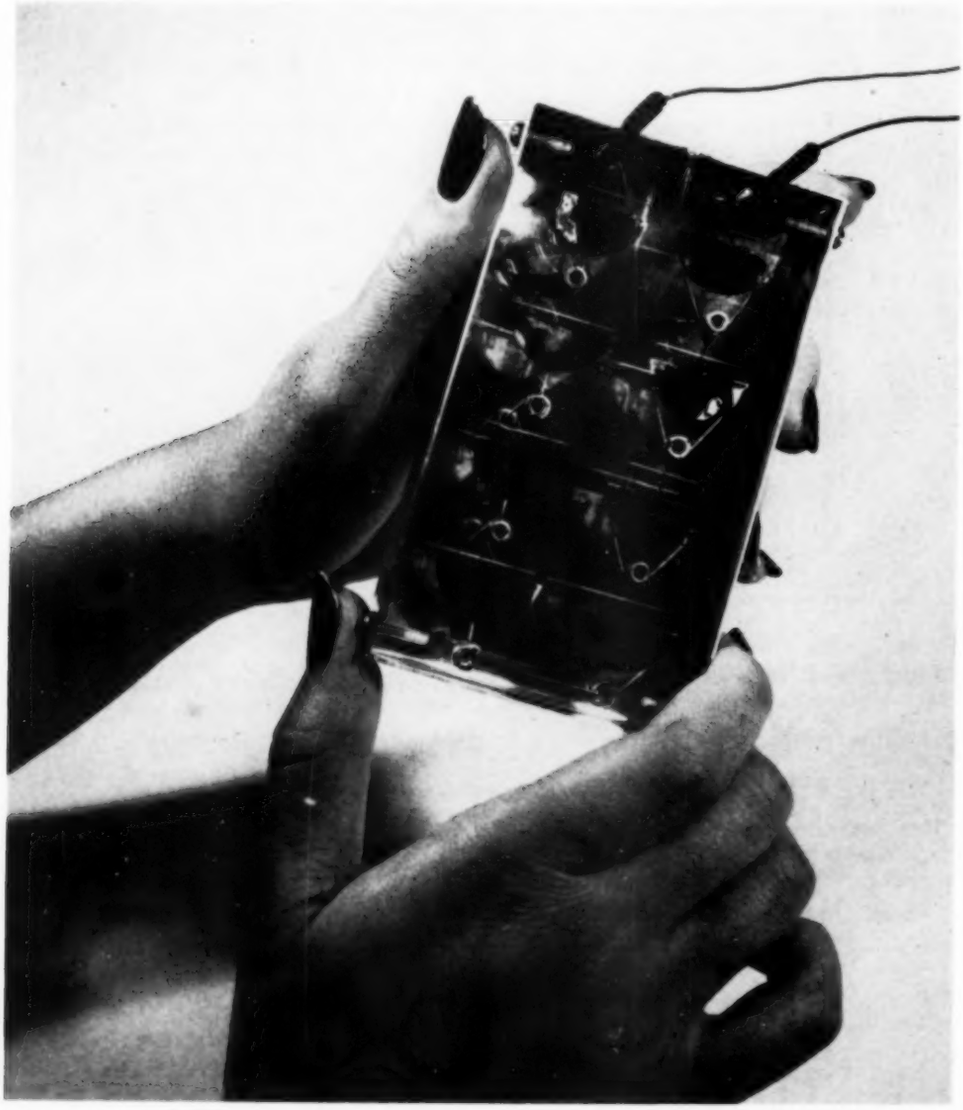
Here is an authoritative and up-to-the-minute account of the newly invented Bell solar battery that is attracting world attention.

Composed of strips of specially prepared silicon, the battery converts sunlight directly and efficiently into electricity. And sunlight is cheap!

Although the battery is still in the experimental stage, its efficiency, which compares favorably with steam or gasoline engines, is far greater than that ever before attained by a photoelectric device.

To harness the sun's energy in the service of mankind is a problem which has challenged the mind of the scientist for centuries. And yet, although the sun supplies over a thousand trillion (1,000,000,000,000,000) kilowatt hours of energy daily—comparable with all the reserves of coal, oil, natural gas and uranium found on earth—man has never been able to convert more than a small fraction of this energy directly to his use.

The Bell Solar Battery, first demonstrated by Bell Telephone Laboratories in April of this year, provides a possible solution to this problem. This solar battery is the first successful device to convert useful amounts of the sun's energy directly and efficiently into electricity. It was developed by a three-member team of Bell Laboratories scientists—G. L. Pearson, C. S. Fuller and D. M. Chapin, physicist, chemist and engineer, respectively.

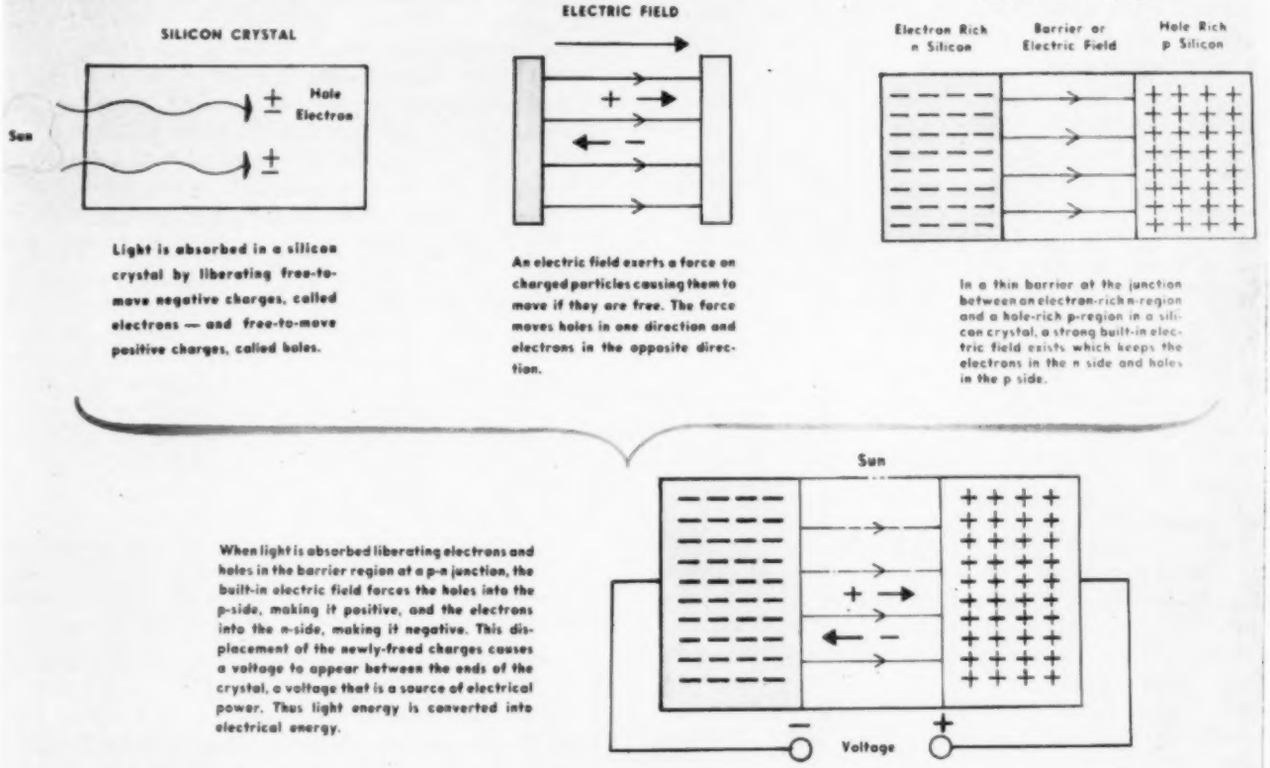


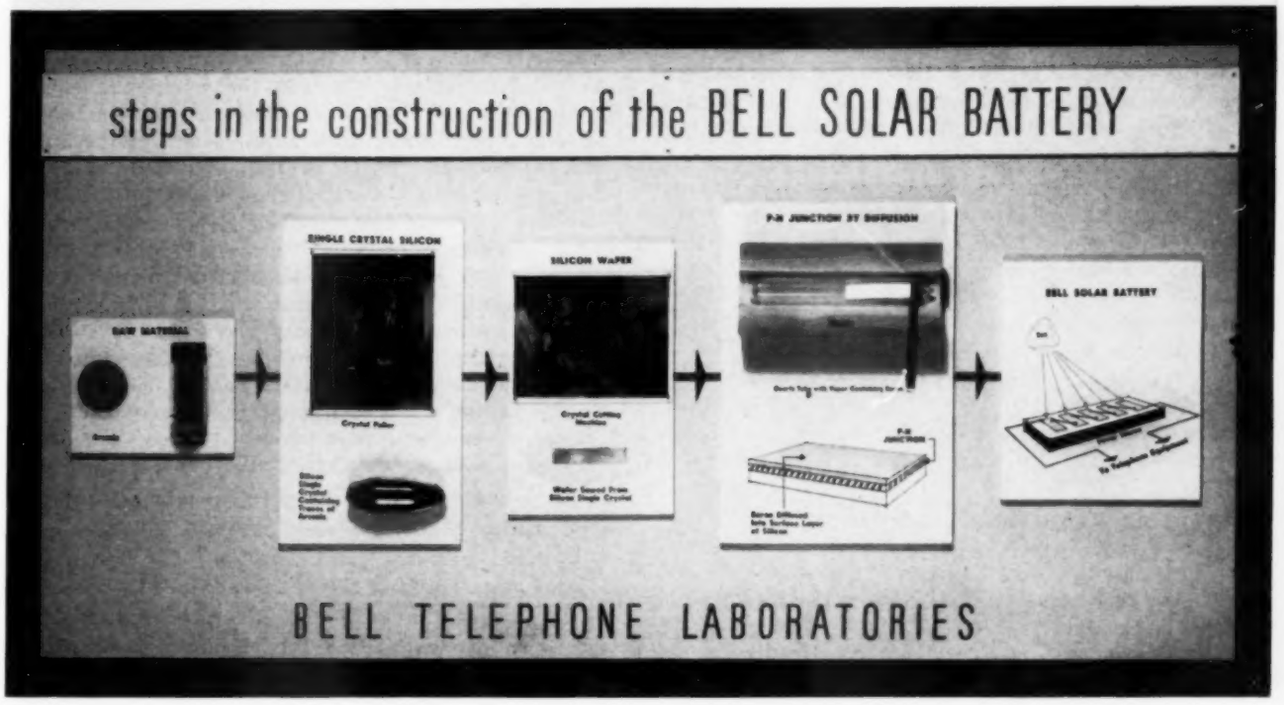
A SOLAR BATTERY invented at Bell Telephone Laboratories is the first successful device to convert useful amounts of the sun's energy directly and efficiently into electricity. The battery, composed of strips of specially prepared silicon, has used the sun's rays to power the transmission of voices over telephone wires and to power a transistor radio transmitter. Although the solar battery is still in the experimental stage, the Bell System envisions its use in telephony, in such equipment as mobile radio-telephone systems and as sun-powered battery-chargers for rural telephone systems. The Bell solar battery was invented by a three-member team of Laboratories scientists, G. L. Pearson, C. S. Fuller and D. M. Chapin.

An amazingly simple-looking device, the solar battery is made of strips of specially prepared silicon. One of the earth's most abundant materials, silicon is a semiconductor, chemically related to germanium, the material used in most transistors. The key to the newly devised technique for converting the sun's energy is the introduction of a minute trace of phosphorus into the body of the silicon and a small amount of boron into a microscopic layer at the surface of the silicon strip.

When sunlight falls on the solar battery there is a voltage of one-half volt between the front and back surfaces of each strip. By connecting many strips

how the BELL SOLAR BATTERY works


SILICON CRYSTAL
Sun
Hole
Electron
Light is absorbed in a silicon crystal by liberating free-to-move negative charges, called electrons — and free-to-move positive charges, called holes.
ELECTRIC FIELD
An electric field exerts a force on charged particles causing them to move if they are free. The force moves holes in one direction and electrons in the opposite direction.
SILICON P-N JUNCTION
Electron Rich n Silicon
Barrier or Electric Field
Hole Rich p Silicon
In a thin barrier at the junction between an electron-rich n-region and a hole-rich p-region in a silicon crystal, a strong built-in electric field exists which keeps the electrons in the n side and holes in the p side.
When light is absorbed liberating electrons and holes in the barrier region at a p-n junction, the built-in electric field forces the holes into the p-side, making it positive, and the electrons into the n-side, making it negative. This displacement of the newly-freed charges causes a voltage to appear between the ends of the crystal, a voltage that is a source of electrical power. Thus light energy is converted into electrical energy.
Sun
Voltage



in series a much higher voltage is obtained. For example, 230 strips connected in series give 115 volts, which is the same as that used to operate the electric light and other appliances in a home. In bright sunlight the total solar radiation falling on one square meter of the earth's surface amounts to about 1000 watts. The new solar battery converts six per cent of this energy directly into electricity, which amounts to 60 watts per square meter.

This six per cent figure approaches the efficiency of steam and gasoline engines, in contrast with other photoelectric devices which have never achieved more than one per cent. And with improved techniques, Bell Laboratories scientists and engineers who have been working on the project expect to increase the efficiency substantially—probably to ten per cent—and possibly even further. The theoretical limit of efficiency in conversion by this type of device is about 22 per cent. Nothing is consumed or destroyed in the energy conversion process and there are no moving parts so, theoretically, the device should last indefinitely. The fuel, of course, is free.

Although work is still in the experimental stage, actual use of the solar battery in communication equipment is a strong possibility. For example, silicon solar batteries may be used as power supplies for low-power mobile equipment, or as sun-powered battery chargers which can be used at amplifier stations along rural telephone systems. The sun battery has been used successfully to operate small motors, light switchboard lamps, and power radio transmitters carrying both speech and music.

In addition to the solar battery other silicon devices are being studied at Bell Laboratories. These include a lightning protector for telephone lines which would be more compact and easier to maintain than those now in use. Also under study are power rectifiers which can convert very large amounts of alternating current to direct current. An important feature of these is that they can operate at much higher temperatures than other crystal rectifiers now in use.

While the new silicon devices—solar battery, power rectifier and lightning protector—perform a variety of unique electrical functions, they all depend essentially on one feature known as the "p-n junction." P-N junctions built into germanium single crystals are the basis for the junction transistor, invented at the Laboratories. All of the silicon devices, however, perform in ways that are at present impossible for germanium; their unique electrical properties depend on the substitution of silicon as the crystalline material in which p-n junctions are made by the controlled introduction of traces of impurities.

Silicon p-n junction rectifiers, for example, have reverse currents at least 1,000 times smaller than those of germanium. Temperature rises of at least 150° C. above room temperature may be tolerated by silicon, whereas germanium and other semiconducting rectifiers are limited to about 40° C. rise. At reverse voltages above breakdown, silicon p-n junctions show remarkably flat voltage saturation characteristics, and the breakdown voltage is controllable over a range from a few volts to several hundred volts.

The genesis of these silicon devices can be traced back to at least the first decade of the century when semiconducting crystals provided one of several competing "wireless detectors." From this competition the vacuum tube emerged the decisive victor. As radio frequencies moved persistently upward, however, the tube lost its advantage, and in the early 30's, Bell scientist R. S. Ohl showed that the erratic "crystal detector" could in fact be made reliable and reasonably efficient, and that it was capable of taking a leading role in extending the useful frequency range to higher and higher limits.

In the study of crystal detectors, the silicon to which the metal point was applied was found to be "spotty," indicating non-uniformity in material then available. Although these impurities could not be detected chemically, Bell Laboratories scientists found that careful freezing of silicon, starting at the top of the melt and working slowly downward, segregated the impurities so that a considerable part of the ingot would be uniformly satisfactory for use in microwave detectors. Ohl discovered, however, that this process automatically produced in such ingots the first known p-n junctions. They were imperfect and inefficient but were nevertheless the prototypes of all these devices.

After the p-type impurity had been identified as boron and the n-type impurity as phosphorus, the first synthetic p-n junction was made by deliberately adding these impurities to molten silicon and by diffusing them into solid silicon. These junctions were of considerable scientific significance. The researchers went on to find that other elements whose electronic structures resembled boron and phosphorus behaved similarly when added to silicon as impurities.

After World War II, William Shockley and his group at Bell Laboratories attacked the many challenging problems in the physics of semiconductors that were posed by the silicon studies. In the course of this work, John Bardeen and W. H. Brattain invented the point-contact transistor, in germanium rather than silicon because the former was more easily rendered extremely pure. Shockley constructed the complete theory of p-n junctions and junction transistors, and with his colleagues established the experimental conditions required to realize in germanium the tremendous potentialities of the theory. Meanwhile, Bardeen and G. L. Pearson attained a systematic understanding of the physics of both n-type and p-type silicon, thus providing an important part of the scientific foundation underlying silicon devices.

The science learned with germanium predicted that p-n junctions built into very pure silicon single crystals would perform many functions for which germanium was not well suited. Such silicon devices are ideally adapted for computers and switching elements, for solar conversion, and for all kinds of transistor action at higher temperatures.

(Continued on Page 116)

Water - Managed or Mismanaged?

● By **James B. Lackey, Ph.D.,** *(Columbia University)*
PROFESSOR OF SANITARY SCIENCE, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA

Water may no longer be taken for granted.

America now uses more water per capita than any other country. Of necessity, we are becoming increasingly concerned about our supply. We must learn to mine, conserve, treat, regulate, and allot water. It has become scarce and costly.

This timely article which discusses the situation in general, gives especial attention to pollution, how it occurs, how it may be prevented or removed, and its effects on health, industry and economics.

Here is valuable information for the general reader as well as for the science teacher.

●

Introduction

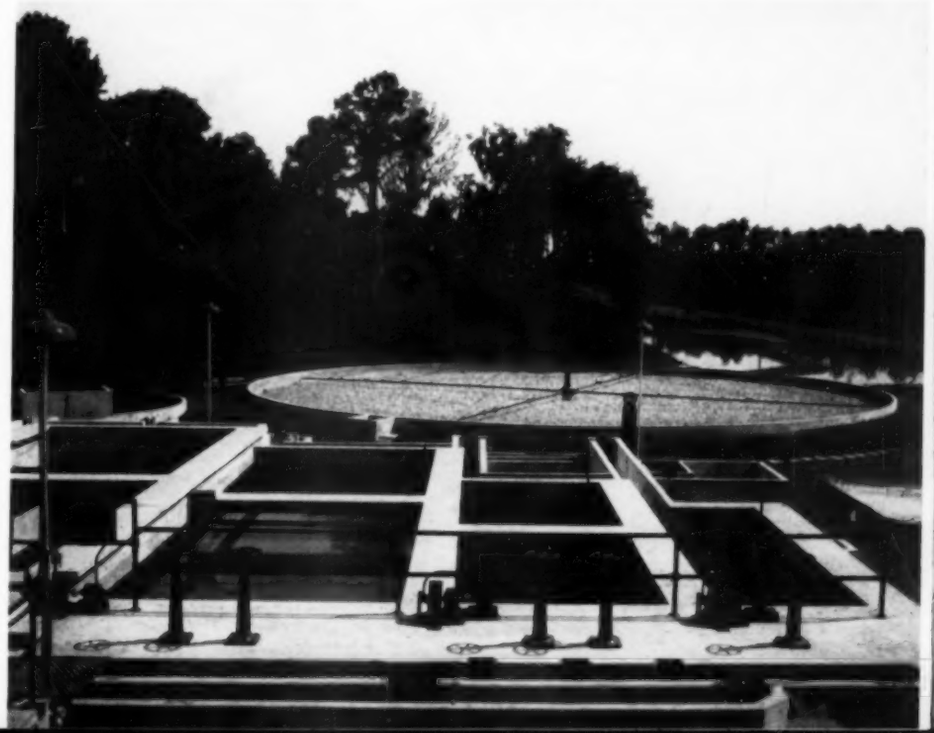
Man cannot create a single material desire or necessity. He can only change or adapt those materials he finds on this planet, molding and evolving them to fit his needs. With human populations mushrooming it ill befits us to misuse a single material asset.

Pure water is one of the most taken-for-granted assets man has. Until recently it did not have to be mined, conserved or treated in any way. True, over long periods of time it gradually became scarce in given areas, such as the cliff dweller areas of southeastern United States, but those people simply moved elsewhere. Early man made his home where there was enough water to drink, provide fish or shellfish and slake the thirst of his game, then later his domestic animals and crops. Eventually, man dwelt where there was water for cleansing, for industrial processes and finally for conditioning his air. Today we have entered a period of competition for water to serve all these needs and recreation as well. Now water is mined, conserved, treated, regulated and allotted. Water is scarce and costly—guard it!

Water shortages, coupled with ever-increasing costs to consumers, require an appraisal of what constitutes good water, the proper use of water and how much a user is rightfully entitled to. The first use of course is for drinking—potable water is a necessity for man and domestic animals. Household demands are second, because of our inherent desire for cleanliness. Industrial use, then recreational use also have good cases. All of these demand clean water.

Pollution is a term frequently used today in regard to many natural waters. It may mean the presence of domestic (human) sewage, containing dangerous (pathogenic) bacteria and obnoxious tastes and odors as a result of the sewage. It may mean offensive discoloration from dye wastes; inorganic acids, alkalies or salts from chemical industries, which kill fish and render the water unfit for drinking by cattle or man. Introduced organic wastes from distilleries or breweries may add large amounts of putrescible matter which in putrefying exert a powerful demand for the dissolved oxygen of the water. A large demand so depletes the oxygen as to suffocate fish or other animals in the water. Such deoxygenation is termed biochemical oxygen demand (BOD) and is measured in numerical units. In other words BOD is a measure of strength of a waste. Domestic sewage has a strength of about 150 parts per million of BOD. Packinghouse and distillery wastes may run as high as 25,000 parts per million of BOD. Organic poisons, such as cyanides, may enter natural waters to be dangerous to all life. Domestic sewage, animal sewage from farms and fertilizer washed from cultivated fields may cause highly undesirable algal and other growths. In short, almost anything man adds to natural water will pollute the water. Not even the ocean is safe; oil, tars and other refuse from ships or coastwise industry are a menace, while shellfish areas and bathing beaches are frequently closed because of sewage contamination.

A MODERN INSTALLATION for treating domestic sewage at the University of Florida. In the foreground, clarifiers allow much of the solid matter to settle out. Beyond is a trickling filter over which the clarified sewage is sprinkled to oxidize putrescible matter before going into the lagoons beyond. Fish live in these lagoons.



INDUSTRIAL POLLUTION. In the lower right a lighter stream of industrial water enters the darker Merrimack River at Lawrence, Massachusetts.

The History of Pollution

Primevally, the creeks and rivers, lakes, bays and oceans probably never were polluted. Usually they were clear because they drained forested or grass covered areas. Of course erosion occurred, especially in areas subject to long dry periods, and in sufficient magnitude to build great deltas. But silt is not usually regarded as a pollutant and settles out quickly. Actually, Mother Nature used it before the advent of man to blanket and bury plant and animal remains and prevent their pollution, by decay, of natural waters. It seems probable that before man's advent most waters were clear, free from suspended matter most of the time, with no odor (unless from sulfur springs), free from taste and color (unless draining cedar or sphagnum swamps), and with a BOD of less than 4 parts per million. Fish and other aquatic animals were abundant and the water was saturated with dissolved oxygen.

The first pollution of natural waters began when men began to collect in dense populations, living adjacent to water because it served for drinking, for such cleansing of food and person as was done and for transport. It also served man to carry away or disperse any and all refuse. The result was that a stream would become an open sewer. However, almost until the Industrial Revolution, the per capita use of water was very small, and while the streets of such cities as Rome, early London and Paris at first were feeders of sewage to the Tiber, Thames and Seine, the quantity was small, even though concentrated. The Industrial Revolution greatly accelerated the misuse of streams for many processes required large amounts of water—wool scouring, the retting of flax, fermentation industries and the concentration of animal slaughterhouses, as examples, needed water to carry away their refuse. Gradually the sewers were put underground in some of the larger cities, but no idea of sewage purification was entertained.

Eventually (about 1850), medical men began to connect certain diseases, such as typhoid fever, with the foul water used for drinking purposes. The result was an attempt to purify water used for drinking, and the first sand filters were put into use. It took a long time: Dr. Snow stopped an epidemic of cholera in London in 1854 by removing the handle of a pump which served as a contaminated source of water and the focal point of the epidemic; and by 1856 all London water was filtered. This removed most of the pathogenic bacteria and greatly reduced disease.

Aspects of Pollution

The presence of disease causing (pathogenic) bacteria in water is one phase of pollution. Most of these bacteria come from human digestive tracts, and since many of our large cities are on or near rivers, their sewage pours the bacteria into the rivers. Anyone using river water nowadays usually has water which has been filtered and disinfected with some chemical to kill such bacteria.

Another phase of pollution is industrial waste from our many factories. People usually will not drink water which is not clear, and they object strongly to any taste or odor. Water containing carbolic acid (phenol), for example, in extremely small quantities has a disagreeable taste, and many organic substances cause odors. Industrial wastes have so many adverse effects on receiving waters that each one is usually considered separately and methods devised for its treatment. The effects previously referred to—poisoning, oxygen depletion, physical fouling by detritus (small solid particles of any sort), overfertilization, etc.—have led to stringent laws and regulations on the part of state boards of health. An industry whose workers and families may comprise a population of 2,500 might produce a waste with a population equivalent of 25,000 people. Treatment would require a system capable of handling a population equivalent of 27,500 people, but it would be unfair to require the 2,500 inhabitants to stand the expense of such a plant, so the industry is required to purify its own wastes.

Nor is it fair for a city to pollute a river so that a town downstream cannot use the water. Within state boundaries this is not such a problem, but rivers cross state lines and they form boundary lines. The Federal Government has set up at Cincinnati, Ohio, a Sanitary Engineering Center, one phase of whose work is to deal with such problems, and now several states may enter into a joint compact to safeguard water in which they are jointly interested. In the case of the Rio Grande, the agreements are between the United States and Mexico. While this primarily concerns the amount of Rio Grande water each is entitled to, it also concerns water quality.

Variation of Natural Waters and Its Results

Such examples as described above could be multiplied indefinitely. Enough has been said to show that whatever man adds to water exerts an influence as spreading as the ripples from a thrown stone, and often a deleterious or baneful influence. What do we know of the nature and composition of natural waters?

The mineral content of natural waters varies greatly. In the ocean it almost reaches constant salinities. This salt content includes some of practically every chemical element, and where it varies (near the mouths of large rivers, landlocked bays, etc.) produces changes in the behavior and content of sea-dwelling animals and plants. Oysters, for example, will not "set"—produce a crop of young oysters—when in salinities as high as the open ocean; on the other hand, when unusually large fresh water flows decrease salinities too much near the head of the Chesapeake Bay or the mouth of the Mississippi, the adult oysters in those areas die.

In rivers the dissolved minerals may be very low if such streams originate in a region of granitic rocks; high if from limestone rocks. This is abundantly reflected in their biotas (living plants and animals), poor in the former, rich in the latter. The primary determining factor for life in any body of water is the amount of phosphate and nitrate present; other materials are usually present in sufficient quantities so as not to be limiting factors. When nitrates (NO_3) are present in quantities as high as 0.2 parts per million, and phosphates as high as 0.015 parts per million, certain organisms (plankton) often grow in such huge numbers as to be noticeable because of color or other characteristics and are termed blooms. Such richness of running water in nitrates and phosphates is rarely natural; in most cases it comes from human activities. Sewage treatment plants do not extract these two substances, hence streams below cities often have a very rich plankton. Examples of plankton rich streams are the Scioto of Ohio, below Columbus, rich because of sewage even though that sewage is treated; the Crawfish in Wisconsin, because of farm and pasture drainage; and the Peace in Florida, rich because of phosphate mining. This richness may be a real problem to waterworks men because of shortness of filter runs and tastes, odors and color. Enriched water often quickly develops a rich growth of microscopic suspended plants and animals (plankton) which clog filters and on dying release oils or other matters which can impart taste, odor and color to a water.

Lakes may be well fertilized by the above three causes, and in addition may gradually build up their nitrate and phosphate content until some microscopic plant suddenly blooms (reproduces) heavily and exhausts the fertilizer. The results of lake blooms are often more striking, especially since they tend to produce heavy blooms of blue-green algae, which often pile up on shore and produce nauseous odors by decay.

Ocean Waters and Pollution

Ocean water has been traditionally pure, and for offshore waters this is probably as true today as ever. Generally such water does not contain enough organic and inorganic matter to support much life. A liter of water from the open sea will have a few microscopic organisms in it, which can usually be counted in hundreds whereas inshore water of bays, fiords and estuaries have millions of such organisms per liter. There are occasional blooms of organisms in offshore waters such as the recent "Red Tide" off the Florida west coast. The red color here is due to a microscopic flagellate *(Gymnodinium brevis)* and the effects of this bloom are lethal to fish and highly offensive to man when the "Red Tide" and the dead fish drift inshore. Such occurences are very rare, and even in bays pollution is rare. Today ocean and bay front land is being rapidly bought up by the millions of people who want to swim, boat, fish and lie on the sand, and who see more and more ocean front shut off from public access. Cities like Boston, New York and San Francisco buy vast stretches of beach for public use, and make rigorous tests to see that that water along such beaches is free from pollution.

Wherever oceanside cities grew up, disposal of their wastes lagged. As a result beaches around New York and San Francisco harbors have been closed due to sewage pollution and the danger of water-born disease. Many shallow areas where the public could dig clams, fish for blue crabs, take oysters, or fish have likewise been closed. The sewage and industrial wastes of Philadelphia and Trenton (and their industrial surroundings) have completely eliminated the multimillion dollar shad fishing industry from the Delaware, a story repeated in the Raritan, the Hudson and elsewhere. In this case, pollution of ocean water ruined a fresh water fishery, the shad not being able to penetrate the plugs of heavily polluted water at the mouths of the rivers. This situation is being overcome today, partly by the construction of huge sewage treatment plants, partly by disposing of wastes far at sea. Laws forbid ships to discharge tar and oils (real nuisances on bathing beaches) close to land. These substances are lethal to ducks, seafowl, shellfish and young fish. Only recently in salvaging a wrecked tanker in the Chesapeake Bay the oil was pumped out into the Bay, whereupon the state took legal action against the offenders because of oyster destruction. Elaborate studies are being made in the Gulf of Mexico to prevent pollution by the oil wells being drilled in tide water.

Ocean pollution of other sorts occurs also. Great South Bay, along the ocean side of Long Island, was the home of the famous Blue Point oysters which commanded a premium price. It was also the locale of much rentable hotel and cottage space and of summer homes for it was a beautiful body of water suitable for bathing, boating, fishing and crabbing, to say nothing of the many baymen whose livelihood depended on its oysters and clams. About two decades past the Long Island duck industry began to grow vigorously on the streams emptying directly or indirectly into Great South Bay. The excreta from several million of these ducks so heavily fertilized the Bay that today during the normal feeding months for oysters the water teems with a particular species of microscopic green plant or alga. This bloom does not rise rapidly to a peak then die down to be succeeded by blooms of other species, as is usually the case. Instead, it persists many months and acts as a dominant growth, with other species either suppressed or present only in small numbers. The alga

(Continued on Page 114)

Will Physics Disappear from our High Schools?

• By W. C. Kelly, Ph.D., *(University of Pittsburgh)*
DEPARTMENT OF PHYSICS, UNIVERSITY OF PITTSBURGH, PITTSBURGH, PENNSYLVANIA

Here is a well-reasoned plea for a strong effort to stimulate increased interest in the study of physics before school boards find it necessary to eliminate it from the high school curriculum because of lack of student interest.

After pointing out the value of studying physics regardless of what the pupil's future vocation may be, Dr. Kelly offers seven reasons for the continuing decline in physics enrollments and suggests what should be done to correct the situation.

Regardless of what your science teaching field may be, the physics problem is one in which you should be deeply concerned.

●

We confront a paradox when we consider the status of physics in the secondary schools of this country. On the one hand, the importance of physics in our national life increases daily as the results of physics research pour forth. On the other, the interest of our high school pupils in physics, as judged by enrollments, drops toward the vanishing point. Physics has completely changed our pattern of military defense, has created whole new industries, has explored nebulae and probed nuclei, and has worked a fundamental change in our thinking about the great world and the small. Yet in 1948, a representative year, less than 6 per cent of our high school pupils were engaged in the study of this truly basic science.

I would like to give you some statistics which, although they do not exhaust the information available, do illustrate the trend in physics enrollments. The percentage enrollment in high school physics in the United States during the past fifty years or more is what the mathematicians call a monotonically decreasing function of time. That is, the percentage enrollment always falls and never rises. Table I, based on data taken from NEA reports[1], presents the percentage of the total national high school enrollment taking physics in the year indicated.

TABLE I

Percentage National Enrollment in Physics

1895	22.8%	1922	8.9%
1900	19.0%	1928	6.8%
1905	15.7%	1934	6.3%
1910	14.6%	1948	5.8%
1915	14.2%		

[1] I am indebted to Mr. Eugene Peckman of the Pittsburgh Public Schools for supplying this information.

Percentage enrollments in physics for the Pittsburgh Public Schools[2] and for the Allegheny County Public Schools[3] in recent years are given in Table II.

TABLE II

Percentage Enrollments in Physics

Pittsburgh Schools		Allegheny County Schools	
1948	5 %	1951	6.1%
1952	7.5%	1954	6.0%

I believe that anyone who is informed about developments in our high schools can supplement this information with his own experience. Physics is fading from the high schools. Three sections drop to two and then to one. One by one, the smaller high schools drop physics from the curriculum. And so it goes.

One might argue, however, that the picture is not so bleak as the tables indicate. As total enrollments rise, the number of physics pupils does increase even though the percentage enrollment falls. Furthermore it is not quite fair to use the percentage of *total* high school enrollment as an index of interest in physics since physics is usually taken only by seniors. Hence, our national percentage enrollment of 5.8 per cent for 1948 should be multiplied by roughly four, and therefore rises to about 24 per cent. To curb excessive optimism at this point, however, I must point out three things. First, over 75 per cent of our high school population has no contact with physics, a science that is transforming our civilization. Second, the enrollment is going down or, at best, is stationary at a low level. Third, our monotonically decreasing curve of enrollment has a foreseeable end-point. School boards and high school administrators are neither willing nor able to continue elective courses in which few students show interest.

This evidence of declining interest in physics on the part of high school pupils may well make teachers think. Does physics have something to offer pupils? Is it properly a part of secondary education? Or should physics—like Greek and some other subjects—be dropped from the high school curriculum? I would guess that most physics teachers feel that it would be a disaster if all high school physics courses were discontinued. Teachers of Greek probably felt the same way about their subject, however, so let us be careful as we consider the place of physics in the high school curriculum.

In defense of high school physics, I first claim that physics can contribute much to the education of any

[2] Courtesy of Mr. Eugene Peckman.
[3] Courtesy of Mr. George Cassler.

pupil whether he is going to be a steelworker, a lawyer, a sportswriter, an artist or a physician. We live in a physical environment. The physical world beats upon our senses unceasingly with an infinity of impressions. Out of centuries of toil, out of countless observations, we have produced the laws of physics, relationships that bring a little order into the physical world. We believe that we see unity behind the bewildering diversity. Surely, any boy or girl should be helped toward an understanding of this oneness in the physical world. Why is the sky blue, a cloud white, and the sunset red? What causes lightning? Why does the earth have seasons? How do we hear? Well-founded answers to these questions should be as much a part of a teen-ager's store of information as how to coax another two miles per gallon from his car.

However, we must not only understand our physical environment, we must also control it. Human beings living in civilizations which are far advanced in technology have replaced one set of dangers by another. They have exchanged the rigors of the natural world—cold, flood, disease, hunger—for the dangers of misuse of machines and other products of science. In this country, most of us are in less danger of freezing to death in the winter than of being blown up by failure of our gas furnaces. The intelligent use of machines requires an understanding of the principles upon which those devices are based. Almost always, these are the principles of physics.

We have been talking about how a course in physics can be of value to any pupil. Let us remember, however, that physics contributes to the preparation for various occupations. Physics is helpful to those who will enter college to study for the scientific professions — engineering, medicine, dentistry, chemistry, physics itself, and many others. Engineering school faculties are placing greater emphasis upon physics than ever before. The engineering student who has not had a strong course in high school physics works under a handicap. This applies with almost equal force to predental and premedical students. Physics can be helpful in a vocational sense to those who will not go on to college. I shall not go into this at any length, but I believe that most physics teachers would not find it difficult to explain how an electrician, a steelworker, an auto mechanic, the secretary to an engineering firm, and so on, would find a knowledge of physics useful to them in their work.

Perhaps you will concede that there are many reasons why high school pupils should study physics. Why then are we unable to arouse the interest of pupils in physics? I would like to offer some opinions on this subject.

(1) In spite of the national and international effects of developments in physics during the last ten years, most people do not know what physics is about. We need to explain to our high school pupils, their parents, and their school counsellors what physics is and what physicists do. We need pamphlets, movies, and popular lectures to explain physics to the public.

(2) Most people believe that physics is impossibly difficult. Physics teachers have long been proud that theirs is an exacting science. They have often favored the brilliant pupil and tolerated the average one. Many college and university teachers share their attitude. Now, however, we must realize that many average pupils in our technological age need a course in physics. We must convince our pupils that a person of moderate ability who has studied algebra and plane geometry can succeed in a high school course in physics.

(3) A single approach to physics for pupils of varying abilities will not work. Either the gifted pupil will be bored or the less-gifted pupil frustrated. We should form "fast" and "slow" classes wherever possible.

(4) The supply of well-trained teachers of physics is far short of our needs. The influence of the teacher on the attitude of the pupil—and, indeed, of the community —toward physics is usually decisive. I recommend to you the report of the Conference on Nationwide Problems of Science Teaching in the Secondary Schools[4].

(5) We are probably making the mistake of trying to present too much material in the high school physics course. Teachers should agitate for a thorough revision of the content of this course. Colleges and universities are moving rapidly in the direction of more intensive and less extensive courses in physics. There seems little reason why high schools should not do the same.

(6) Many schools have given up demonstration experiments and student laboratory work in physics. Introductory physics loses much of its interest when it is separated from its experimental basis. Effective student experimentation and lecture demonstrations are expensive and time-consuming, but both are essential.

Will physics disappear from our high schools? The answer, it seems to me, is not an automatic yes or no, but rather depends upon how well we solve some of the problems listed above. Downward trends in enrollment are also evident in high school chemistry and mathematics. It is clear that those of us who are interested in the future of the physical sciences and mathematics in the high schools should join in seeking solutions to many common problems. ●

[4] Copies of the report may be obtained without charge from Mr. Elbert C. Weaver, Phillips Academy, Andover, Massachusetts.

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The Communist party is not a political party like any other. It is a secret, conspiratorial organization imposing on its members a discipline and a regimentation of thought quite alien to the normal political parties of a democracy. Its standards of ethics are radically different from the ethical principles on which a free society, freedom of thought, freedom of research and teaching, are based. The distinction between heterodoxy and conspiracy is relevant here: the university must insist on the tolerance of honestly held and frankly proclaimed differences of opinion, and its faculty must be free to engage in ordinary, open political activity; but is must protect itself, and cooperate in protecting the country, against any conspiracy which, if successful, would destroy all freedom. —LEWIS WEBSTER JONES
Rutgers University

The Program and Purpose of the Future Scientists of America Foundation

• By John H. Woodburn
ASSISTANT EXECUTIVE SECRETARY, NATIONAL SCIENCE TEACHERS ASSOCIATION, WASHINGTON, D. C.

The high school science teacher is the most influential single person in providing manpower for science. By his counsel he starts a chain reaction. But both high school and college enrollments in science are dwindling alarmingly, percentagewise. The nation's need for scientists and engineers is not being met.

Important corrective measures are being taken by several agencies.

This article tells what industrial grants have enabled the National Science Teachers Association, through its agency the Future Scientists of America Foundation, to accomplish during 1954.

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High school enrollment figures, especially for classes in science and mathematics, present facts that are subject to disturbing interpretations. American traditions emphasize the values of education. High standards of educational opportunities for America's youth have always been maintained, even at considerable sacrifice. Why do so many of today's young people reject the educational opportunities that are available to them? Scarcely half of our young people stay with organized education through high school graduation. As to science enrollments, the facts are even less complimentary and more disturbing.

Science teachers have a phenomenally successful record for keeping alive America's vigorous spirit of scientific enquiry, discovery, and invention. The small fraction of our youth who do enroll in science courses receive a caliber of instruction adequate to maintain a constant flow of spectacularly capable engineers and scientists into our economy. The question is — Are enough young people receiving instruction in science?

With our economy and national prestige becoming more and more dependent upon science, can we maintain the American tradition with so few of our youth arriving at college entrance age capable and wanting to continue toward engineering and scientific careers? Can a citizenry exercise competent judgment on subjects involving science if less than one in five have as much as one high school course in physics, one in four a chemistry course, and not many more than half, a biology or general science course? The National Science Teachers Association says "No" to these questions. With the Future Scientists of America Foundation as its agency, it has turned to industry for money to develop a constructive action program.

From the very beginning, the Foundation has tried to strengthen all programs designed to attract more capable young people toward scientific, technical, and engineering careers. There is quite a challenge in the 2,800,000 young people of junior and senior age who are not enrolled in either chemistry or physics. There are nearly 3,000,000 high school science students for whom their teachers offer no national program of incentives or guidance services toward keeping alive their science interests. More than half of America's 60,000 science teachers are not dues-paying members of any active local, state, regional, or national science teachers' organizations.

Anyone close to high school students during the war years of the 1940's and the equally unsettled post-war period extending into the 1950's knows about the very complex forces which affect a student's decisions as he plans his high school course of study. Even more complex are the events and circumstances which determine whether or not the student will decide to remain in school through to graduation. The complexity of the factors affecting the holding-power of our schools and, particularly, the attractiveness of science courses, render very difficult the development of a remedial program that is appropriate and stands a good chance of being effective.

Following the counsel from many individuals and advisory groups, the first action of the Foundation was to inventory teachers' opinions and experiences with sponsored incentive programs and guidance services. The report of this study, *Encouraging Future Scientists: The Situation*, gave advisory and administrative groups a basis for planning the Foundation's 1954 program. The features of this program are:

1. *Science Teacher Recognition Awards:* Encouragement to share their best science teaching ideas with other teachers. (This and the following program receive special support from the American Society for Metals. See item 5 in the bibliography.)
2. *Science Achievement Awards for Students:* Provide a way to encourage individual and small group projects in science.
3. *F. S. A. Student Chart Making Contest:* Recognition for students who prepare outstanding science teaching charts. (In 1954, this program received special support by the W. M. Welch Manufacturing Company.)
4. *Science Teachers Summer Conferences:* Fellowships for selected teachers to serve as research teams to explore problems of concern to the science teaching profession. (The 1954 West Coast Conference, with the special support of the Crown Zellerbach Foundation, was devoted to a study of school science laboratory activities.)

(Continued on Page 108)

Research in Petroleum Chemistry

● **By Frederick D. Rossini, Ph.D.,** *(University of California)*
SILLIMAN PROFESSOR AND HEAD, DEPARTMENT OF CHEMISTRY, DIRECTOR, PETROLEUM RESEARCH LABORATORY, CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PENNSYLVANIA

Here is a brief account of some 400 man-years of fundamental research in petroleum chemistry, written by one of America's most distinguished scientists.

Extending over more than a quarter of a century, the work has been devoted to a study of the origin, recovery, production, composition, and properties of petroleum. Two of its special projects are outlined.

Although supported by the petroleum industry through the American Petroleum Institute, the object of the research has been to obtain basic information of broad application rather than of immediate commercial applicability.

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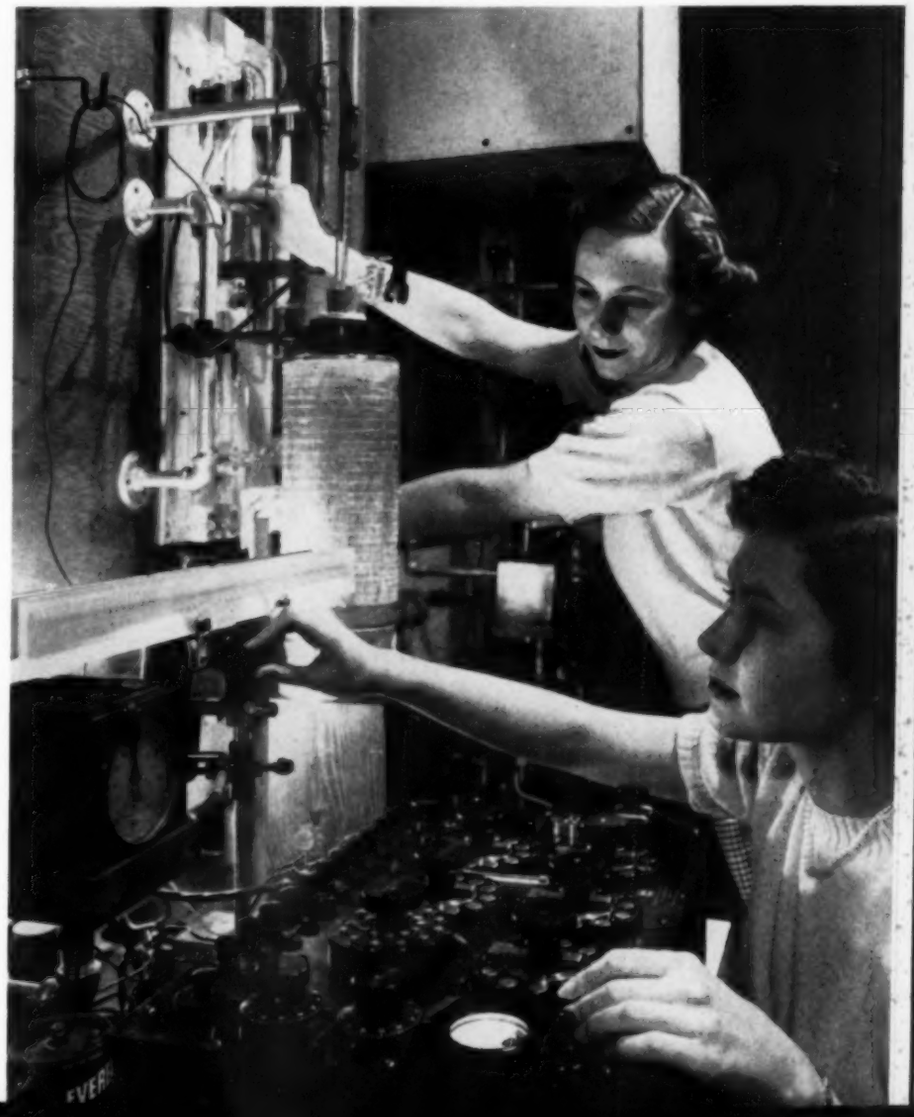
Petroleum, one of our most important natural resources, is a very interesting and intriguing chemical substance. Although it contains small amounts of sulfur, nitrogen, and oxygen compounds, petroleum is largely hydrocarbon material, with molecules ranging in size from 1 to 50 or more carbon atoms and comprising a diversity of such molecular types as paraffins, cycloparaffins (or naphthenes), and aromatics (including benzene, toluene, naphthalene, and related compounds). Because petroleum contains many hydrocarbon compounds which are of themselves important chemicals of commerce, and because chemicals derived from petroleum are increasing greatly in number and importance, petroleum has come to be called Nature's storehouse of chemicals.

Early man long wondered about the thick dark liquid that in certain lands oozed from the earth or floated on natural water. He learned many centuries ago that this strange substance would burn and give out great heat and light. Petroleum, or some portion thereof, as bitumen or asphalt, is mentioned in the Bible. History records that asphalt was used by man as early as 3800 B.C.

Petroleum was found as an oily liquid exuding from the surface of the earth in tar springs, or on shores of lakes, or rising from springs beneath the beds of rivers. On the surface of water, petroleum would appear as a thin film, with rainbow colors, or in the form of dark globules that could be separated mechanically. In these forms, and in these limited quantities, petroleum was found in many places on earth,—notably Rumania, Persia (now Iran), Italy, Trinidad, Cuba, India, and later the United States. In Western Pennsylvania, an enterprising business man by the name of Kier put up petroleum in bottles, labeled Kier's Rock Oil, and sold it as a medicine for the cure of many human ills.

In 1859, the famous Drake well was completed, near Titusville, Pennsylvania, to become the first petroleum well in history. This well, drilled to a depth of 69.5 feet, produced about 25 barrels of crude oil per day,—in those days an extremely large production. But we all know how the production of petroleum in the continental United States since then has grown to astonishing proportions, as indicated by the following figures,

FIGURE 1. Women chemists serve the industry in determining the purity of hydrocarbons. API Standard and Research hydrocarbons have their purity evaluated from accurate measurements of freezing points. With the apparatus shown here, these chemists of the Petroleum Research Laboratory at the Carnegie Institute of Technology are adjusting the freezing point apparatus and measuring temperatures to 0.001° C. with platinum resistance thermometers.



in millions of barrels per year: 0.002 in 1860; 26 in 1880; 64 in 1900; 443 in 1920; 1,300 in 1940; and 2,200 in 1952. Since 1880, the United States production has been about 70 per cent of the world production.

Notwithstanding the enormous production, the proved reserves of crude oil in the United States have also increased to large proportions, being as follows in billions of barrels: 3 in 1900; 7 in 1920; 19 in 1940; and 28 in 1952. For the continental United States, the ratio of proved reserves to the annual production has decreased somewhat over the years, being 21 in 1910, 16 in 1920, 15 in 1930, 14 in 1940, and 13 in 1950. It is seen from these figures that the ability of man to locate and recover petroleum is keeping reasonable pace with his present needs.

Prior to about 1900, the refining of petroleum consisted essentially in using the process of simple distillation to separate crude oil into the fractions we now identify as gasoline, kerosene, gas-oil, and lubricating oil. Most of the early commercial use was of the kerosene for illumination and of the lubrication oil for lubrication. In those early days, the gasoline fraction was a drug on the market and, because of its volatility, its physical disposal posed a real and hazardous problem. After about 1900, however, there was no longer any worry about what to do with the gasoline, because more and more of it was needed to operate the increasingly great number of automobiles appearing on the American highways. Soon there even became a shortage of gasoline in terms of the quantity of it which could be obtained from a barrel of crude oil. Fortunately, the development and introduction of the thermal cracking process by the petroleum industry about the time of World War I served to increase the quantity of gasoline and at the same time to dispose of the surplus gas-oil by the thermal cracking of the later into the much needed gasoline.

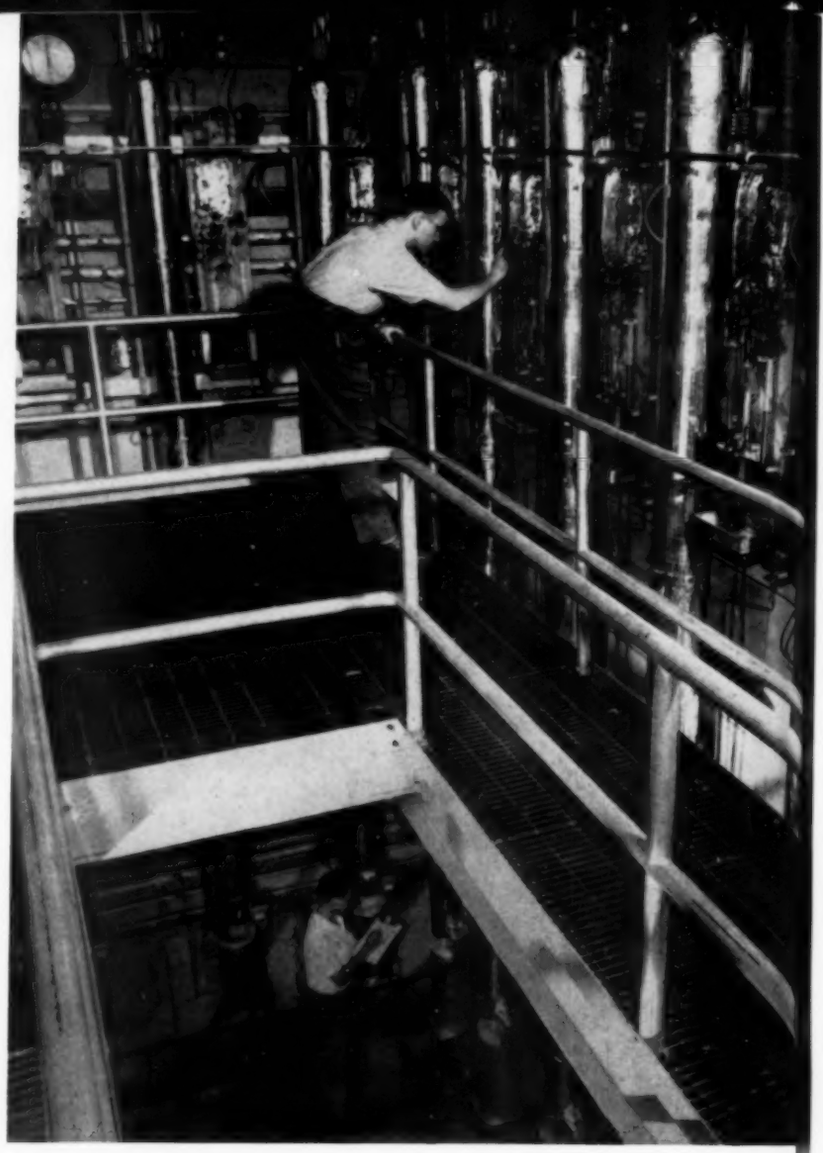


FIGURE 2. Nature didn't make petroleum simple. Petroleum is one of the most complex mixtures of nature. The tall distilling columns shown here in the Petroleum Research Laboratory at the Carnegie Institute of Technology operate continuously 24 hours per day, 7 days per week, with fractionating efficiency equivalent to 200 theoretical plates, unlocking the secrets of the composition of the raw material of the petroleum industry.

After the end of World War I, the petroleum industry began to be seriously concerned about the chemical constitution of its raw material. It was quite clear that increasing fundamental knowledge of the mixture of chemical compounds constituting petroleum would lead not only to a more economical use of petroleum in the existing processes, but also would lead to the production from petroleum of entirely new substances for the needs of man in peace and for his protection from aggressors.

In 1925, the petroleum industry, through the American Petroleum Institute (API), embarked on a program of fundamental research on the origin, recovery, production, composition, and properties of petroleum. The purpose of this program was to obtain fundamental, basic, and background information concerning petroleum which would benefit the industry as a whole in fields of broad, but primarily non-competitive interest, and would not be directly applicable to industrial operations or processes.

Among the many API research projects that were carried on under this program, we single out for discussion here the two with which this writer has been connected, namely the API Research Project 6, on "Analysis, Purification, and Properties of Petroleum Hydrocarbons", established in 1927, and involving to date about 350 man-years of work, and the API Research Project 44, on "Data on Hydrocarbons and Related Compounds", established in 1942 and involving to date about 85 man-years of work.

The API Research Project 6 carries on the following investigations:

1. Fractionation, analysis, and isolation of hydrocarbons from petroleum. The general problem set before the Project was to start with a large quantity of a selected original crude petroleum known to have intermediate properties, and by the appropriate interlocking of suitable physical methods of fractionation to resolve the petroleum into its major constituent compounds.

FIGURE 3. Site of the Brett No. 6 well, near Ponca City, Oklahoma, on March 10, 1940, with Frederick D. Rossini (Director, API Research Project 6) at the left, and Bert H. Lincoln (then Chief Chemist, Continental Oil Company) at the right.

2. Development and operation of fractionating processes. In order to separate the petroleum into its components, fractionating processes of high separating power are developed and operated.
3. Purification of API Standard and API Research hydrocarbons. To identify compounds isolated from petroleum, synthetic API Research hydrocarbons are purified for reference and research. To satisfy the needs of the industry for standard hydrocarbons for calibrating spectrometers, API Standard hydrocarbons are purified.
4. Measurement of physical properties of API Research hydrocarbons. For purposes of record and identification, accurate measurements are made of the simple physical properties of the highly purified API Research hydrocarbons.

The methods of fractionation used in the work on the API Research Project 6 include the following:

1. Distillation (involving a liquid phase and a gas phase).
   a. Regular, at one pressure (at 30, 55, 214, and 760 mm. Hg).
   b. Alternately at different pressures (at 30, 55, 214, and 760 mm. Hg).
   c. At very low pressures (0.01 to 0.1 mm. Hg).
2. Extraction (involving two liquid phases).
   a. With one solvent phase
   b. With two solvent phases
3. Adsorption (involving a liquid phase and a solid -adsorbed phase).
   a. Regular
   b. With one or more added components
4. Crystallization (involving a liquid phase and a solid phase).
   a. Regular
   b. With selected solvent
5. Formation of molecular or clathrate compounds.

Among the foregoing fractionating processes, separation by size of molecules is produced by distillation at one fixed pressure, whereas separation by type of molecules is produced by distillation alternately at different pressures, distillation azeotropically, extraction, and adsorption.

Figure 2 is a photograph of the distillation laboratory of the API Research Project 6. Normally, this laboratory operates continuously 24 hours per day, every day in the year. The laboratory has 13 complete distilling columns. One of the representative columns, as Column 5, has a fractionating power of 200 equivalent theoretical plates, a charging capacity of 6 liters (about 1-½ gallons), a throughput of 800 ml. per hour, a reflux ratio of 200 to 1, and a product rate of 4 ml. per hour. This means that a full charge requires about 1500 hours or 2 months of continuous distillation at 760 mm. Hg.

Figure 3 is a photograph of the Brett No. 6 well near Ponca City, Oklahoma. This well was drilled in 1919, producing at a depth of 3870 feet, was placed on the pump in 1926, and produced until 1936, when the well was plugged and abandoned because of salt water encroachment. In 1928, there was taken from this one well 600 gallons of crude petroleum, which has been under investigation by the API Research Project 6 since then. This picture, taken in March, 1940, shows the writer (on the left) with Mr. Bert H. Lincoln, then Chief Chemist of the Continental Oil Company.

A total of 130 different hydrocarbons have been isolated from the Projects' representative petroleum by the methods referred to.

We have summarized the composition of the various broad fractions of the Project's representative petro-

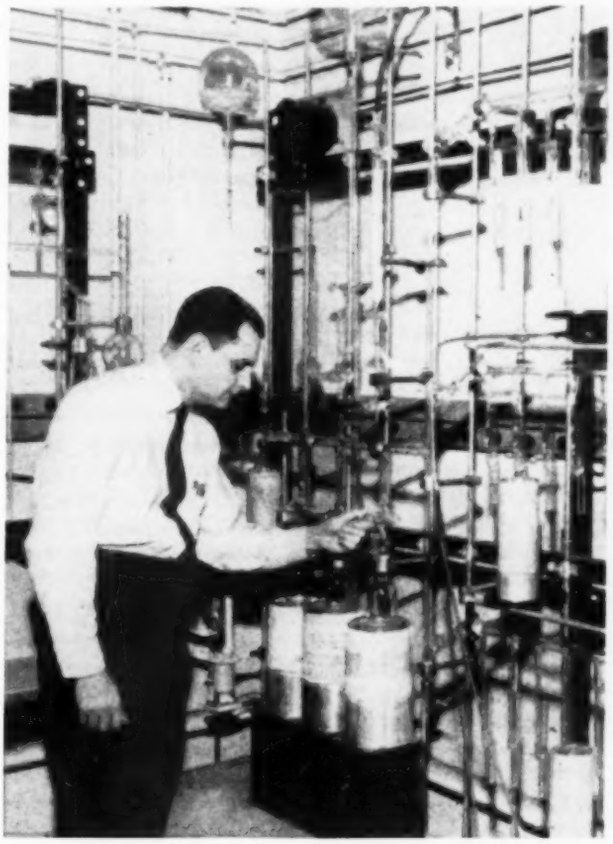


FIGURE 4. Purity must be safeguarded. Special precautions are used to preserve the purity of the API Standard and Research samples of hydrocarbons. In the apparatus shown here in the Petroleum Research Laboratory at the Carnegie Institute of Technology, air is removed and the highly purified hydrocarbon material is sealed "in vacuum" in small glass ampoules.

leum in terms of the various classes or types of hydrocarbons. The work has included examination of the heavy gas-oil and lubricant fractions although no compounds have yet been separated from these fractions.

About 1940, the Advisory Committee for the API Research Project 6 decided that, having learned a great deal about the hydrocarbons in one representative petroleum, the Project should gain some knowledge of how petroleums from different fields varied. The Project's one representative petroleum, from Oklahoma, was intermediate in type. The gasoline fractions from six additional representative petroleums were selected, to represent large production in different areas of the country and to be as different as was known at the time. By means of an extended but relatively short cut procedure involving the fractionating processes of distillation and adsorption, analyses were made of the major components in these seven representative gasolines. From this work, the following conclusions were reached:

FIGURE 5. *Worth 10 times its weight in gold.* The highly purified API Standard sample of 1-methyl-2 isopropylbenzene shown here is made available to the laboratories of the petroleum industry at $50 for one-eighth of an ounce. These samples are used with spectrographic instruments to "fingerprint" hydrocarbons. From such "fingerprints," the petroleum industry determines the composition of its products and uses this information in its search for better fuels, lubricants, and other materials.

1. The components in the gasoline fraction of each petroleum may be placed in five main classes:
   a. Normal (straight chain) paraffins
   b. Branched paraffins
   c. Alkyl cyclopentanes
   d. Alkyl cyclohexanes
   e. Alkyl benzenes
2. Within each of these classes, the individual compounds occur in proportions which are usually of the same order of magnitude for different petroleums.

Figure 1 is a photograph showing two women chemists determining the purity of API Standard hydrocarbons from precise measurements of freezing points.

Figure 4 shows the apparatus used to seal "in vacuum" the API Standard and API Research samples of hydrocarbons. Figure 5 shows one of the sealed-up units of the API Standard hydrocarbons, a sample of 1-methyl-2-isopropylbenzene, 99.94 mole per cent pure.

The investigations of the API Research Project 44 are aimed to make available to the laboratories of the petroleum industry, and to the technical world in general, all of the data on hydrocarbons and related compounds, in the form of tables of selected values of physical and thermodynamic properties, and catalogs of infrared, ultraviolet, Raman, and mass spectral data.

The entire available data are examined and appraised. The data are correlated. Original calculations are made, as necessary. "Best" values are selected. The data are put into useful form and distributed nationally and internationally to the free world. Descriptions of the original methods and calculations are published in scientific journals. And, finally, the tables of physical and thermodynamic properties are maintained up to date by revision at appropriate intervals.

One of the complications arising in the work on hydrocarbons is the existence of so many isomers. For example, there are 35 different nonanes, C_9H_{20}, and 75 different decanes $C_{10}H_{22}$. Some of the isomers have properties as different as day and night.

By means of suitable correlations of properties with molecular structure, it is possible to obtain reliable values of properties for compounds that have never yet been prepared in any laboratory. Appropriate correlations with temperatures (or pressure) serve to yield values for temperatures (or pressures) not before measured.

Over 400 man-years of work have gone into the research that I have described here so briefly. The work has covered over a quarter of a century. Many investigators have come into the work and graduated from it. It is not possible for me here to give adequate acknowledgment to all who have contributed to the work. ●

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One of the primary goals of science teaching for non-scientists is to make the subject matter attractive to the student. Examples of free choice, as in adult education, indicate that most people prefer to take courses in literature—the "great books"—and, to a lesser extent, history. On this score, frankness demands our admission that science courses do not attract students. In adult education it seems to be the rule that only about five per cent of the course offerings are scientific; if the number is higher in our colleges and our secondary schools, the reason probably lies in the science requirement for graduation which forces students to make such course. The average non-scientist shies away from science courses because they are difficult and uninteresting. The physical sciences require mathematics and the power of abstraction, and the biological sciences require a strong stomach.

—I. BERNARD COHEN
Harvard University

Botany as a Hobby

● By **W. E. Buker**
RESEARCH ASSOCIATE, DEPARTMENT OF PLANTS, CARNEGIE MUSEUM;
PERRY HIGH SCHOOL, PITTSBURGH, PENNSYLVANIA

An article to make science teachers think.

Read how an amateur (self-designated) has turned his knowledge of botany into a valuable open-air hobby that has brought him much enjoyment. His studies in the fields and woods of Western Pennsylvania have enriched the botanical lore of the region.

Other amateurs can, if they will, make contributions to science as valuable as his. Mr. Buker tells how it may be done.

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In these times of relatively shorter working hours, longer vacations and earlier retirement, worth while and interesting leisure time activities offer something of a problem. Science instructors might well devote a little time to a consideration of this aspect of the courses they teach. Just as an English course which does not inspire an interest in good reading habits in the pupil must be labeled a failure, so does a science course fall short if the student is glad to close his book on the subject once he has credit for the course.

The purpose of this article is to suggest the advantages of Botany as a promising hobby for the amateur. For the last ten years the author, with a little group of amateurs like himself (always encouraged by professionals like Dr. O. E. Jennings and Dr. L. K. Henry, of the Carnegie Museum of Pittsburgh), has roamed over Western Pennsylvania (and beyond) collecting plants for the Carnegie Museum. Since I have found this activity a very rewarding experience, I would like to mention some of the advantages of Botany as a hobby.

First, the subject seems inexhaustible. As one who had always tackled a subject first by studying textbooks, it was an interesting switch to go first to the plants themselves. As our knowledge of plants, at first slight, began to grow, it was interesting *then* to go to the manuals and experts (always interested and helpful) to get needed information. We first tried to become familiar with the common wild flowers of the region, a not inconsiderable undertaking. Then we wanted to see as many as possible of the plants which grow without cultivation in our area. Soon we were checking up on old records, looking for rare plants, or even trying to find plants never before recorded in the area. In some cases we succeeded.

Plant hunting leads the devotee out into the open air and sunshine — sometimes rain — far from the crowded cities where most of us make our living. It is particularly attractive to those whose lives are normally sedentary. It is pleasant to get up early, take off in the wet misty morning, drive over mostly deserted highways to our usually remote destination, and start up the mountain, along the river bank, around the lake or across the sopping bog in search of some elusive plant. By noon we are tired and hungry enough to enjoy our scanty lunch, which we wouldn't regard very highly at home. And then we begin to plan the afternoon's jaunt. When we get home, often late at night, pleasantly tired, we are well satisfied if we have seen a new plant, or met an old friend in a new setting. The scenery we enjoyed, or the accidental meeting with a deer, woodchuck, pileated woodpecker or copperhead, we regard in the nature of a bonus.

Botany is a field in which it is possible for the amateur to make a real, if small, contribution to science. Most herbaria are inadequately staffed and short of funds. They cannot always do without help all the things they would like to do, or that ought to be done. These institutions are usually ready and eager to encourage and aid intelligent amateurs with their hobbies, and are glad to furnish expert guidance so that the hobby will be channeled into something worth while to both the amateur and to the institution.

One possible field of activity is the filling in of gaps in collections over the area in which the institution is most interested. Our experience has been with the Carnegie Museum of Pittsburgh, primarily concerned with the plants of Western Pennsylvania. Here we find many areas, such as Presque Isle in Erie County, Pymatuning Swamp in Crawford County, Ohiopyle in Fayette County, Glade Run Bog in Somerset County, and most parts of Allegheny County, have been intensively collected. These places have received attention because of their unique interest, or because of their easy accessibility to centers of botanical activity. Most of the old collectors used railroads, rode horses, or just walked. Because of these limitations, many regions were largely neglected. For example, we have found that Armstrong, McKean, Forest, Cameron and Clinton counties, as well as large areas in other places, are relatively uncollected. Using modern transportation facilities, it is not too hard for us to cover territory largely overlooked by the old-timers.

In any herbarium it is not difficult to find old or unverified records of plants that need checking. Some old records cannot now be duplicated, since farming, lumbering, fire and the growth of cities, to name a few agencies, have destroyed many old stations; but it is surprising the number of old records that can be brought up to date when old sites are investigated. For example, all our Western Pennsylvania records of the Putty-root *(Aplectrum hyemale* [*Muhl.*]*Torr.)* were over fifty years old. But we found 22 plants near Waynesburg, in Greene County, in April, 1952[1]. Similarly, the beautiful Queen's Lady's-slipper *(Cypripe-*

dium reginae Walt.), although known from a few old records was thought to be nearing extinction in Western Pennsylvania. We have been able to find the plant recently in considerable numbers in a couple of calcareous bogs near Union City, in Erie County. To cite one more example, Arethusa *(Arethusa bulbosa L.)* formerly grew in Pymatuning Swamp, Crawford County, and at Presque Isle, Erie County, but had apparently become extinct in these areas. We searched in vain for several years over Western Pennsylvania, following all leads. Finally, in June, 1950, we found ten plants in bloom in a remote bog in Fayette County, where it had never before been reported.

Closely related to the search for rare plants is the attempt to extend known ranges of plants. A common reason why a given plant is rare in a certain region is that the area may be along one of the fringes of its range. Several species whose range is normally to the north of us, persist as relicts in the bogs of the glaciated northwestern counties of Pennsylvania. Examples are Labrador Tea *(Ledum groenlandicum Oeder)* and Bog Rosemary *(Andromeda glaucophylla Link)*, growing together in the Sulphur Springs Bog in Warren County. Such plants are supposed to have persisted in a few micro-climates while plants formerly associated with them have moved north in the path of the retreating glaciers.

Another group of plants seems to be moving in from the south and west as the climate grows gradually warmer, or as areas formerly forested are cleared, permitting establishment of species characteristically more southern in distribution, or perhaps typical of prairie conditions. Of many possible examples, we mention two Ferns, Mountain Spleenwort *(Asplenium montanum Willd.)* and Pinnatifid Spleenwort *(Asplenium pinnatifidum Nutt.)* both of which we found near Muddy Creek Falls in Butler County. They were not formerly known so far northwest in Pennsylvania. Dr. David Berkheimer, a dentist of Reading, Pennsylvania, and an enthusiastic collector, has extended the known range of several southern and eastern plants into Bedford County.

Intensive study of a local area is another way in which the amateur can contribute to the knowledge of the botany of a region. Careful collecting over several seasons, and at differing seasons of the year, is highly desirable before a local flora can be published with any pretense to completeness. For Western Pennsylvania, several county floras have been published, and much work has been done with a view towards possible future publication. The writer, with Dr. L. K. Henry, Curator of Botany of the Carnegie Museum, Pittsburgh, compiled *A Check List of the Vascular Flora of Allegheny County, Pennsylvania*, published by the Western Pennsylvania Botanical Society, and, separately, by the Carnegie Museum[2]. Workers active in a local area are John Lewis in Fayette County, Max Henrici in Beaver County, and Dr. David Berkheimer in Bedford County. These local floras, while limited in scope, are, if carefully done, of immense value to professionals in preparing larger works.

The amateur may prefer to work on some particular family or group of plants. Our own group became interested early in the native Orchids. After about ten years' collecting over Western Pennsylvania, the author, with Dr. L. K. Henry and Dorothy Long, both of the Carnegie Museum Staff, is getting out a study on *The Wild Orchids of Western Pennsylvania*, now in press. Another recent example, by Dr. Henry, a professional, is his recent publication in *Castanea*, the organ of the Southern Appalachian Botanical Club, of "The Violaceae of Western Pennsylvania," where a new species is described[3]. Other similar studies are contemplated both by professionals and amateurs.

Another possible specialty is the search for sports, color forms, double flowers, and other aberrations. These mutations are of interest from several points of view, for example, to gardeners. A double form of the common Bloodroot *(Sanguinaria canadensis L.)* was found in Michigan several years ago, and is now offered to gardeners at a fancy price. If another personal reference may be pardoned, a few years ago the late A. J. Deer, F. H. Beer and I found near Warrendale, in Allegheny County, a form of the well-known Mayapple *(Podophyllum peltatum L.)* having blush-pink flowers and plum-colored fruits. The same plant (apparently) has been described *(Podophyllum peltatum f. Deamii Raymond)*[4]. I remember seeing near Dixmont in Allegheny County a pure white form of the Fire Pink *(Silene virginica L.)*, whose blooms are normally deep red. Now that I find the plants are apparently unnamed, the plants in question seem to have disappeared.

The study of Botany may lead easily into other hobbies, such as wildflower photography. Max Henrici, who conducts a Nature Column in the *Pittsburgh Sun-Telegraph*, as a side-line in his study of the flora of Western Pennsylvania, has accumulated perhaps the finest collection of color slides of our native plants known to exist. The late Dr. Andrey Avinoff, former Director of the Carnegie Museum, preferred to paint his flowers in water colors. These water colors, in part, constitute the second volume of Jennings & Avinoff's recent monumental publication[5], and are unique in the field.

Plant study is associated in the minds of many with gardening. All of our garden flowers are either wildflowers native somewhere, or are derivatives of them. While indiscriminate collecting of wildflowers is to be decried, particularly among the rarer species, it is still possible to develop an interesting collection of native wildflowers in a garden, if judgment and control are exercised. In my own case, interest in gardening gradually ripened into a preference to study the plants as they grow naturally.

The study of plant distribution is likely to lead to a need for an acquaintance with several other sciences. Why do plants grow where they do? Why are some rare and some common? Attempts to answer such questions are likely to lead into the fields of geology, climate, soil composition and chemistry. These only hint at the possibilities.

(Continued on Page 113)

An American Alchemist

• **By P. Schuyler Miller**
EDITORIAL STAFF, FISHER SCIENTIFIC COMPANY, PITTSBURGH, PENNSYLVANIA

An alchemist in the United States?

Yes, indeed.

Mr. Miller tells a highly interesting story about a scientific unknown, a most unusual person who tried, but failed, to make spendable gold. For this and other reasons the peculiar community he founded failed to flourish.

Only recently have his alchemistic efforts come to light.

GEORGE RAPP (1757-1847), an American alchemist.

It was the life-study of a Pittsburgh businessman which catalyzed a historian's curiosity and revealed an American alchemist who lived and worked only 16 miles as the crow flies from the Duquesne University "acropolis."

In the December, 1947, issue of *The Science Counselor* Chester G. Fisher, founder of Fisher Scientific Company, explained how for more than 30 years he has gathered together in Pittsburgh the world's most comprehensive collection of paintings and prints dealing with alchemy and the early history of chemistry. A newspaper account of the Fisher Collection of Alchemical and Historical Pictures came to the attention of Lawrence G. Thurman, Curator of the Pennsylvania Historical Commission's museum at Old Economy, in present Ambridge, Pa.

In the records of the Harmony Society, founders of Economy, and in his exploration of the cellars and garrets of the abandoned village, Mr. Thurman had come upon references and found apparatus which seemed to have been lifted directly out of the 17th Century paintings in the Fisher Collection. He asked Mr. Fisher for help in interpreting his finds.

This account amplifies a report which appeared in *The Laboratory*, Vol. 22, No. 4, after the first inspection of the material at Economy. The research is continuing, with the cataloging of the more than a quarter-million manuscript records of the Harmony Society, and the reassembling of its once famous library.

Perhaps, when the crabbed German script has been translated, the full story of George Rapp, mystic and alchemist of early 19th Century Pennsylvania, can be told.

☆ ☆ ☆ ☆ ☆

The merchants of Pittsburgh and Allegheny, in the year 1829, looked with a mixture of respect and envy on their peculiar neighbors down the river in the four-year-old settlement they called "Economy."

The people were Germans—no novelty in Pennsylvania. Many people remembered when they had first come from the Old Country, back in 1804, and settled on a 5000-acre tract on Conoquenessing Creek near Butler. They stayed for ten years, then sold out and moved to Indiana. In 1824 they showed up again, down the Ohio on the Legionville tract where "Mad" Anthony Wayne had wintered in 1792-93 before he set out to drive the redskins out of the Ohio country.

There were about seven hundred of them now—although they didn't believe in marriage, outsiders were welcome to join the Society—and the Pittsburghers watched in fascination as they put up an enormous woolen mill, followed it with a gristmill, a stream-driven sawmill, a cotton mill, vineyards, a brewery and distillery. They had their own steamboat on the river, their own hotel, a music hall, a whole village of neat little brick houses. And they worked hard.

How hard, the merchants soon learned. Six-foot, white-bearded "Father" George Rapp and his adopted son, Frederick Reichert Rapp, had business agents in every large city from Baltimore to St. Louis and New Orleans. Frederick, as hardheaded a businessman as anyone had seen (and an architect, musician and scientist to boot), was making the town live up to its name: his big, efficient mills turned out goods better and cheaper than the small factories of the region could produce. There was no wage problem, because all property was held in common and everyone shared alike.

The howl of "Monopoly" went up. *The Allegheny Democrat* demanded that the Legislature dissolve the Harmony Society and put it out of business. Scurrilous tales—some of them still circulating—were told

about George Rapp, his peculiar creed, the celibacy he enforced on his community, his prediction of a Second Coming of Christ.

Tongues would really have wagged had the gossips known that in a secluded laboratory George Rapp was trying to make gold.

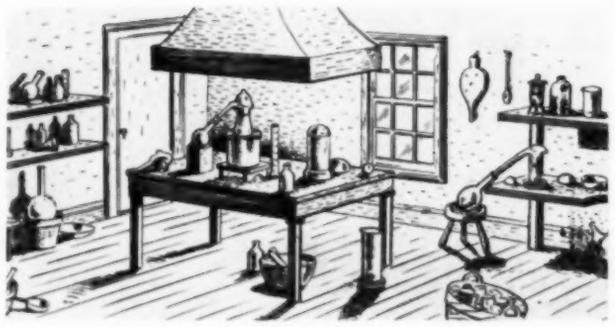
The Laboratory

Puzzling through the Harmony Society records a century after George Rapp's death, Lawrence Thurman learned that a wing behind the Great House was known as "Father Rapp's laboratory." The place had been remodeled in the 1870's when the trustees of Economy built in a big steel vault, but there were traces of the original construction where the old mud-and-straw plaster had broken away.

Mr. Thurman began to poke around in the dark corners of the Great House, to pull down more plaster, to pry under the floors. The soil under the wing, he found, was full of broken glass and stained by what looked like chemicals. He found a whole series of strange snouted glass vessels exactly like the alembics in the paintings of alchemical laboratories in the Fisher Collection. There were gourd-shaped flasks: these were "cucurbits," Mr. Fisher told him, and they had been standard alchemical equipment from the earliest times. There were also several retorts, long the emblem of chemical research.

The chimney of George Rapp's laboratory, opened in the *middle* of the original room. There was no trace of a fireplace: could the chimney have been the vent of a fume hood?

There was no question that Economy had been a scientific as well as an industrial center. Frederick



AN ARTIST shows how Rapp's laboratory may have looked more than a century ago.

Rapp had set up a museum there, and sent to Europe for all sorts of "philosophical" apparatus. George Rapp had a reputation as a healer and the Society's pharmacy was as busy as its mills. Moreover, inventories of the Harmony Society's property listed laboratories in each of the earlier settlements.

But was it chemistry or alchemy that George Rapp studied in his laboratory behind the Great House?

The Alchemists

The evidence is circumstantial, but the answer seems clear: he did both. Aided by Frederick and a Dr. Christophe Müller, George Rapp conducted a school of chemistry as an introduction to the "Great Work" of transmutation.

The roots of George Rapp's creed were sunk deep in the alchemical mysticism of Jacob Boehme, Jung-Stilling, Herder, Goethe, Swedenborg and other religious philosophers of the 17th and 18th centuries. He had their books in his library with the works of the master alchemist Aurelous Philippus Theophrastus Bombasts von Höhenheim, better known as Paracelsus.

The early alchemists, as Mr. Fisher's article pointed out, were trying to recover the "lost" chemical and metallurgical secrets of the ancients. They insured secrecy by using an elaborate shorthand of symbolism. Each substance and each process had its emblem, many of them taken from the ancient lore of magic and the occult. The later alchemists began to give these esoteric symbols a mystical significance of their own.

George Rapp's teachings are full of this alchemical-mystical symbolism. "Twelve gates has the City of Gold," runs a line of one of his hymns. These very words were used by the alchemists to represent the twelve processes which must be followed to make the perfect metal, gold. Twelve circles around a central circle was the alchemical symbol for the Laboratory. And in the floor of the Grotto at Economy, focus of

ALCHEMICAL GLASSWARE found at old Economy (left and right, alembics; center, retorts) shown with George Rapp's 1603 edition of the works of the great alchemist, Paracelsus. The book is open to a description of the process for making the Philosophers' Stone.

George Rapp's mystic creed, Frederick set twelve stones around a central stone.

There is other more tangible evidence to supplement the alembics and the cucurbits. Frederick Rapp made repeated purchases of cinnabar, chief source of mercury—as much as 300 pounds at a time—and mercury was the starting point in the making either of physical gold or of the "aureum potabile," the all-curing Elixir. Frederick's personal notebook calls the metals by their alchemical code-names: Saturn for lead, Mars for iron, Venus for copper and "Sol," the Sun, for Gold.

Then in 1831 the Rapps came face to face with a self-styled alchemist whose followers swore that he "could make 100 pounds of gold a day . . . enough for 100 years."

George Rapp believed that by following his teachings the men and women of the Harmony Society would become the chosen people of the new era to follow a Second Coming of Christ. On his deathbed he was still convinced that he would live until he had led them to Canaan to welcome the returned Lord.

Then, from Germany, came a letter from one "Maximilian, Count de Leon," who styled himself "Ambassador and Anointed of God, of the stem of Judah, of the root of David" and who announced that *he* was appointed to organize the world for the Coming. The time was near, he said, and the place might well be Economy, which he proposed to visit.

Doubtless George Rapp was eager to meet anyone who might have new prophecies to reveal. Doubtless, too, he welcomed the advice of a man who could make spendable gold—for George was laying away in the vault under the Great House a treasure which would take him and his people to the Holy Land.

Be that as it may, the Count de Leon (actually Bernardus Müller) seems to have been as much charlatan and opportunist as mystic. In short order he tried to oust the Rapps and take over the Harmony Society—and its treasury. He failed, but did win away 250 of the Harmonists who founded a new village across the Ohio, the present Monaca. In accordance with Society custom, the seceders got a $105,000 stake from the Economy treasury, but it was soon gone. The Count was called upon to make the gold they needed: none was forthcoming, so the Leonists made a comic-opera march on Economy, were routed, and soon abandoned Pennsylvania for the Red River country of Louisiana.

The School

Frederick Rapp, the practical genius of Economy, conducted a technical evening school which became famous. If the Harmonists could not buy a new machine, someone who had seen it described it to Frederick's class of young engineers and they promptly drew up plans and built the thing. Many of the Harmonists' own production-boosting devices undoubtedly were developed in this school.

On the side of pure science there was Dr. Christophe Müller who served as a kind of free-lance physician, wrote articles on astronomy, studied the fungi of Western Pennsylvania with the great Linnaeus' own microscope (still on display at Old Economy), and filled in his time investigating static electricity with a home-made Ramsden generator whose glass discs had been cut out of a big mirror.

In the Economy archives there is a manuscript manual in the writing of Dr. Müller and Frederick Rapp (who had an incorrigible habit of mixing English, French and Latin with his Swabian German) in which three women—"Louisa," "Caroline," "Frau B"—discuss the fundamentals of physics and chemistry: thermal expansion, "caloric", vacuums, the preparation and properties of oxygen, hydrogen, the metals. This was preparation for an advanced course "entirely different from all that has gone before" (to quote the last lines of the manual).

We do not know yet who the three were, although one may have been George's talented granddaughter Gertrude, who built up at Economy one of the few successful silk growing enterprises in America. We do know who they were *not*, thanks to the "Hildegarde Mutschler" letter.

George Rapp made the Mutschler girl his assistant. The hours they spent locked up in the laboratory, plus Hildegarde's confused, self-important stories of what they did, led to gossip, and Hildegarde's conduct with young men tended to bear it out.

This went on for three years before the girl ran off. George Rapp preached a vehement sermon; he wanted her restored to the Great House and his laboratory. But Frederick sent him a long, violent letter of opposition:

"When you took the girl into your laboratory as your assistant it was more than I could stand," he wrote bitterly, "for I then knew that on account of this the Great Work could not and should not be accomplished."

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THE CUT STONE floor of the Grotto, designed by Frederick Rapp. Twelve stones set around the central disc may have been intended to represent the alchemical symbol for the Laboratory: twelve circles, representing the "Twelve Gates" to transmutation, enclosing the perfect circle of gold.

The Physiological Approach to Zoology

● By Mary A. McWhinnie
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Here is a plea for a change in the conventional approach to zoology that the writer believes will attract better students to the science since it will give them better mental discipline. It provides a logical continuum of thought throughout the animal kingdom, enabling one to understand the "why" of morphology through the "how" of function.

Has too much attention been given to structure and too little to function?

Is it time for a change?

●

The biological sciences have progressed to their present status through many decades characterized by taxonomic identifications, the systematic relationships these have elucidated, and anatomical descriptions of both vertebrates and invertebrates. These studies have given rise to the basic and more standard courses of anatomy, embryology, histology, cytology, invertebrate zoology and others of similar kind. From its earliest beginnings, descriptive morphology, gross and microscopic, was almost if not entirely coextensive with the investigations, the teaching, and the thinking of biologists. It had to be this way, since the animals and plants themselves were the most obvious things that had to be studied.

Classical physiology, for many years the most experimental of the biological sciences, was mainly devoted to the service of medicine. This followed as a natural sequel to the early treatises on anatomy and the need for a better understanding of vertebrate functions. Thus, mammalian or human physiology became the handmaid of the clinical sciences and the concept of physiology was confined to the function of vertebrate systems.

Naturally during the advances of this specialized area of physiology the zoologist was pursing a further detailed survey of the animal kingdom and progressively became more and more experimental. This marked the natural transition from an entirely morphological science toward the functional aspect. That comparative anatomy, comparative embryology, invertebrate anatomy and histology have become essential and unvarying components of our biological curriculum presents patent evidence of a retention of the descriptive and morphological approach to this science. These have been designated as essential areas of classical zoology and are "musts" for one concentrating in this science. One might ask, "Why is it essential to become encyclopedic in structural and morphological detail while it is not essential to understand the most basic functional and dynamic activities in this the most dynamic of the natural sciences?"

More recently there has been a growing tendency to present similarly established areas in animal function. These include areas of special physiology though there still prevails a magnified emphasis on human function. General physiology, by title, has been a more or less consistent element in biological curricula yet in the final analysis was rarely more than a descriptive treatment of human physiology. In this regard the more basic approach of general cellular function has recently been growing in emphasis as evidenced by the growing wealth of literature which presents information on basic protoplasmic activity. This is not to say that past individual investigators have not probed into the fundamental problems of cellular function, but rather to recognize that such a host of literature has not become that organized body of knowledge to be presented to the future biologist. Nor does it yet occupy the same solid position in curricula that characterizes morphological and anatomical areas. The faint recognition of the place of cellular physiology may be noted by the publication of several general physiology textbooks which approach the subject matter from the point of cellular function.

In the past ten years there has been the development of a broad treatment of functional phenomena across wide taxonomic categories. This includes extensive details of functional variations among species as we find a comparable field of detail in morphological variations. This approach promises to offer a more solid continuum throughout the animal kingdom than has anatomy with its wide and often bizarre variations which defy meaningful interpretation. A more meaningful interpretation is found through the physiological approach.

For many years the biological sciences have been envisaged in the minds of many, some professional as well as non-professional, as a descriptive science belabored with tedious memorization, and often no patent rationale for such labors. On the other hand the functional approach demonstrates in a more reasonable way the biotic relationships attempted through anatomy, the use or employment of the anatomical equipment for the accomplishment of the same basic biological needs of the protozoa through the vertebrates. The physiological approach allows for that transition whereby a student begins to understand that the formaldehyde soaked animal or sectioned embryo was once a dynamic organism with problems to solve and meeting these problems through functional adjustments.

It may be apparent to many that often-times students of advanced standing totally lack ideas of biological energetics and broad basic concepts. When confronted with formal training in the dynamic aspects of this science they possess neither an aptness of laboratory procedure nor an ability to detect and discern experimental variables due to underlying functional phenomena. But these capacities can only come from work-

ing with living organisms and understanding the basic problems they are meeting. The danger of the fixity of thinking which can result from encyclopedic study may impede the inquisitive and flexible approach which may become complemented by ingenuity.

Lest the value of morphology and anatomy be misunderstood, however, it is pertinent to note that this aspect is the requisite antecedent to a functional study of a given cell, tissue, organ or system. The architecture of the entity must be understood before the mechanism(s) of operation can be analyzed and interpreted. For example, a learned treatise on the enzymatically controlled syntheses associated with mitochondria and microsomes would be meaningless to one uninformed in the subject of cell anatomy. Similarly, the significance of chemical variation periodically repeated along skeletal muscle would yield little import to one unaware of the microscopic anatomy of muscle and its variation in muscle from different sources.

The converse of this inadequate preparation is equally ineffective, however, and may suffer more severe consequences than these. For example, the student required to memorize the morphology and distribution of cell particulates across great varieties of cells, or required to distinguish between muscle types on the basis of the frequency of periodicity in muscle cells, is left with voluminous useless facts through which no common thread extends and upon which no significant biological concept rests. That is, he has not been required to develop meaningful analysis.

This may lead to several undesirable results. First, is a lack of interest, interest keen enough to derive both useful information and mental acuity in return for the effort put forth. With a lack of interest the burden becomes pointless, and the "course for credit" attitude develops. That this is a reality and not merely a pessimistic outlook finds some support in the fact that at a summer conference on college biology held recently at the University of Oklahoma it was emphasized that biology in general is failing to attract the best students. As a possible cause for this failure it was suggested that, currently, biology is a body of doctrine and not a study of dynamic phenomena that have inherent within them the most fascinating and complex problems of all the sciences. It was further pointed out that there can not be, as has prevailed in the past, a distinction between structure and function since these are inescapably interrelated with one another. We cannot continue to focus our attention on structure, but rather use this in the study of behavior and function in organized biological systems. In the past, the essential dynamic aspects have been inadequately considered.

Emphasis on the dynamic or physiological approach is not an entirely new concept. This has been the intent of many, but despite their efforts, a change from the conventional has not been readily forthcoming. There are perhaps some real reasons why biology has remained primarily anatomical and to a very limited degree functional. Prime among these is the time at which the academic biologist, in whose hands rests curriculum decisions, completed his work. Since the morphological aspects held the center of biological interest for so many years the training of biologists was heavily weighted in that direction. Associated with this was often the lack of training in the physical and chemical sciences, indispensible correlaries of physiology. There prevail even today in many of our institutions, curricula with a major concentration in zoology with no requirements in physical sciences. It is likely that from such a training physiology lapses into a description of vertebrate system function. For example, the dynamics of oxygen transport, whether in a more primitive invertebrate or in man, must be avoided with the simple observation that respiratory pigments have an affinity for oxygen and that this leaves its complex with the pigment and enters cells requiring it. This is presented as a fortitutious fact without the consideration of "how" or "why," and what is accomplished by so doing. It is likewise true that too often the biologist is aware of the oxygen supply and demand but fully unaware of the use of this vitally essential "stuff." The history of oxygen transport and utilization is broadly considered in physiology under the general aspects of metabolism, that is, the biochemistry of protoplasm. Such an approach provides an understanding of the cell and removes from it the simple description which carries little concept of the basic activity of protoplasm—the target of biological investigations.

The growing concern over what appears to be a continuing dominance of morphology to the exclusion of the basic fundamentals of physiology parallels the expanding growth of biochemistry which increases in momentum from year to year. Through this area of knowledge the boundary between biology and biochemistry becomes progressively more vague. It is no longer possible to distinguish clearly, if at all, between the physiologist and the biochemist. Yet in their hands the more fundamental answers of biological systems rest. Without their findings the understanding of morphological data remains a compendium of many facts the understanding of which could be greatly facilitated when function becomes elucidated. To give a common example, the student of comparative anatomy may detail the variations extant in excretory systems comparing freshwater and marine teleosts with respect to variations in glomerular structure. That ancestral teleosts took their origin in fresh water, to which they are hypertonic, and secondarily invaded the marine environment, to which they are hypotonic, explains well the physiological demand for the morphological change to a relatively non-functional glomerulus. Similarly, ecological distribution in terms of successful survival as well as colonization finds greater likeliness when viewed from the adaptation of biological systems. One can easily treat various ecological niches of widely different physical and biotic features when functional modifications corresponding to the different environments are emphasized. This recognizes that organisms possess a basic identity in the operations they perform, they differ only in the mechanisms employed to carry these operations out. The examples whereby physiology can be shown to provide a logical continuum of thought throughout the animal kingdom and whereby one can

(Continued on Page 116)

There's More to a Perfume than Meets the Nose

● By Leonard Stoller
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This paper tells the story of what's in a perfume bottle, how it was obtained, where it came from, and, sometimes, why it is used.

Animals, plants, and synthetic chemicals all help the skilled perfumer provide today's widely used scents.

Did you know there is no such thing as a "synthetic" perfume?

●

Since the days of Cleopatra, pleasant scents have been widely used throughout the world, and for many purposes. Perfumes were employed in religious ceremonies as far back as Biblical days, and for personal adornment by the ancient Egyptians. History records that fragrant materials were considered highly valuable in the early civilizations.

Today, perfume is even more widely used than in the days gone by. There is not a cosmetic now in use that does not contain fragrance materials. And, there are very few dressing tables that do not contain a bottle of enchanting perfume or pleasant smelling cologne. We might add that in this modern age there seems to be no age limit for the use of perfume. The school girl in her early teens has joined her older sister, her mother, and her grandmother in adding that special something to her make-up through the use of heavenly scents.

How many users actually know what goes into the preparation of these wonderfully odoriferous essences? The stories of romance and adventure that are told about the perfume ingredients —ambergris, musk, civet,—and the flower oils—rose, jasmin, narcissus, ylang ylang—add to the mystery of perfume creation, but leave to the imagination of the user the filling in of the exact details. Let us look into a bottle of precious perfume and, as the beautiful odor tantalizes our nostrils, let us, in these pages, go back in time and actually recreate this exotic liquid.

The bottle of fragrance that stands on milady's dressing table is a blend of many products—some natural and some synthetic—diluted in alcohol. Behind each scent lie years of study and ideas, culminating in the creation of the particular scent the perfumer had in mind. He may have prepared hundreds, nay thousands, of formulae before he achieved the one blend which satisfied all the requirements of a fine perfume: originality, beauty, lastingness, and above all, consumer appeal.

In creating his formula, the perfumer may have started first with natural products. Oils obtained from many sources carry with them their own characteristic odors. Among them we find the flower oils which include, in addition to those previously mentioned, orange flower, carnation, lily-of-the-valley, tuberose and many others; the grasses, such as lemongrass and citronella; the spices and herbs, including costus, lavender and rosemary; the wood oils, such as rosewood, sandalwood and cedarwood; and the oils derived from leaves and roots, such as geranium, patchouli, vetivert and orris. There are also the citrus products (some of which are quite common) such as orange, lemon, lime, bergamot and petitgrain; the lichens, such as oakmoss; and finally the gums and balsams, labdanum, myrrh, olibanum, storax and galbanum, which bring back memories of passages in the Holy Bible.

These materials come from the far corners of the world—the South of France, Italy, Brazil, Madagascar and the Island of Reunion—a name which may be only a spot on the map to a high school student, but to the perfumer, it means the source of some of our most treasured oils.

PERFUMERS AT WORK in an aerosol research laboratory preparing perfume materials that are compatible for use in that packaging medium.

At this point, the reader may wonder how these various oils are obtained. This brings us to an important part of perfume production. The flowers must be harvested

at just the right time to obtain the odor for which they are famous. After harvesting, the oils are obtained from them by several methods.

One of the oldest processes is steam distillation. In this process the plants are placed into large vessels that are then filled with water and subjected to heat. As the water boils it turns into steam and, together with the vaporized essential oil which has been extracted from the flower by the heat, rises toward an opening in the roof of the still. The vapors then pass through a series of jacketed coils where they are cooled and, once again becoming liquids, they flow into a container. Here the heavier water settles to the bottom and is drained off, leaving only the essential oil.

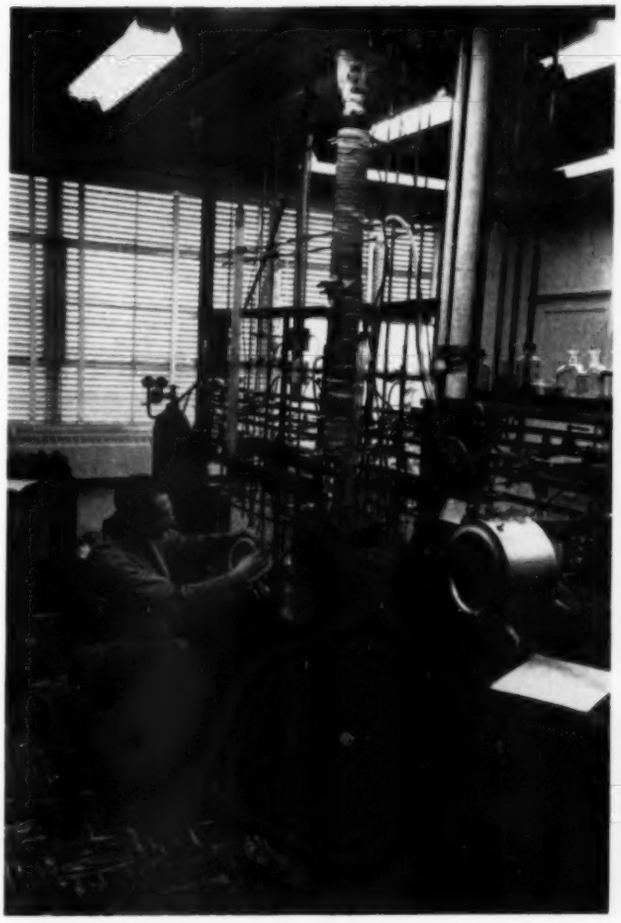
Although steam distillation is an economical method of obtaining essential oils, it is not practical for many of the more delicate and rather expensive flowers. With jasmin and tuberose steam is avoided, and in its place a process known as enfleurage is used. The newly harvested flowers are placed, by hand, on layers of cold, highly refined fats, which are then enclosed in frames or "chasis" where the petals remain for about twenty-four hours. The flowers give off their pleasant-smelling oils which are absorbed by the fats. From these fats a waxy pomade is obtained and processed with alcohol to obtain the usable oil.

There are other methods of obtaining oils which do not require detailed discussion here. These include a very important volatile solvent extraction with solvents such as petroleum ether. In addition, there is maceration in which the petals are immersed in warm fats; and expression, which is accomplished by mechanical pressure.

Leaving the flowers and grasses, we come to the animal products which, though few in number, are important ingredients in fine perfumes. In this category we find ambergris which brings to mind the stories of the early whaling captains; the musks, civet and castoreum. These, some of the most powerful odorants known today, come from lands which are sometimes not easily accessible. The civet cat from Ethiopia; the musk deer from Tibet; ambergris from the sperm whale (found afloat or washed ashore); and castoreum from the beavers of Canada. From the United States, the muskrat has been added to the list of animals from which odorous materials are obtained.

Just what part do animal products play in the creation of fine perfumes? They have a very remarkable lasting quality which they impart to the entire perfume compound, and it is as fixatives that they are largely consumed.

From the natural products we turn our attention to the synthetics, encompassing a great many odoriferous products, some duplicating the odors of nature and others unknown in either plant or animal life. The development of synthetic aromatic materials has opened new doors for the creative perfumer and has placed at his disposal odors that previously he never dreamed of. In addition, it gave to the perfumer less expensive ver-



A Givaudan research chemist at work.

sions of the rarer and higher priced flower oils which he once used sparingly for economic reasons. Today, in factories such as that of Givaudan-Delawanna, Inc., aromatic products are manufactured in quantities never thought possible a quarter of a century ago, products so carefully controlled in all phases of manufacture that they do not differ chemically or olfactorily from batch to batch, a feat even nature does not always accomplish.

Since we are discussing perfume as it is known to the consumer, we must mention that there is no "synthetic perfume." To obtain a perfect blend, both the natural and synthetic products must be used. Each makes its own definite odor contribution to the finished blend and it can be safely said that no perfume could be created without using nuances offered by both nature and science.

Thus we have briefly sketched the story of a perfume. Lack of space limits the scope of our discussion since it would take a complete volume to tell the entire story. We are certain, however, that after reading even this short account the perfume user will be certain to say,

"There is more to a perfume than meets the nose." ●

Fluoridation for Health

● By Mary Lou Duggan
SENIOR STUDENT, MARYGROVE COLLEGE, DETROIT, MICHIGAN

Although numerous large scale tests have clearly proved its value in preventing tooth decay, the fluoridation of water is still opposed for various reasons by certain groups and individuals.

This paper is a careful study of the question, offering facts both for and against.

If fluoridation becomes a problem in your community, you may find this article and its Bibliography useful. In any case you should know the facts about this controversial matter.

●

Fluoridation — what does the word mean to you? Does it cause you to become apprehensive and skeptical; or do you believe, as I do, that it represents the greatest advance toward oral public health thus far discovered by medical science, and as such should be made available to every community in the United States.

The presence of the fluorine ion in water is by no means a new phenomenon. On the contrary, this element is naturally present in water and in a great many of the foods we eat. It was not until the early twentieth century, however, that its presence in water was noted and its full significance realized.

Today, the fluoridation of water is endorsed by the outstanding medical, dental, and public health organizations because of the many advantages it affords. But, there are still individuals who oppose the procedure, and it is this small body of "crusaders" who have prevented the proper fluoridation of the water supplies of many communities.

Why should fluorine, a natural element in foods and water, be added to the public water supply? The reason is this: although a certain amount of fluorine is present in all water, oftentimes it is too small a percentage to be effective for oral public health.

Fluorine, when added to water as a fluoride compound or when it is present in its natural state, has been found to reduce tooth decay in children by as much as 65 per cent[20]. This figure has been established through various long-range tests by many communities in the United States.

One worthy of note is that involving Aurora, Illinois, and Grand Rapids and Muskegon, Michigan. The water supply of Aurora has a natural fluorine content of 1.2 ppm*; Grand Rapids had virtually none until public health authorities added 1 ppm to its supply; and Muskegon, since it had a very minute amount, was used as the control city. In 1945, the percentage of tooth decay was charted among the six to twelve year olds in all three cities, and it was found to be 65 per cent less in Aurora (the city with the natural fluorine content) than in the other two cities. Seven years later the DMF rate** was again charted for these cities, and it was found that the tooth decay of the six to twelve year olds in Grand Rapids had reduced 65 per cent to the level of that in Aurora[12].

These results, then, point out two very important facts: first—that here the presence of 1 ppm of fluorine in water reduced tooth decay by approximately 65 per cent; and second—that artifically introduced fluoride is equally as effective as the natural. Similar results have been achieved in tests of other communities throughout the United States†.

Fluorine produces this effect primarily between the ages of six and seventeen. During this time the enamel of the permanent teeth is becoming calicified. Once calcification takes place, fluorine is no longer effective. Although adults cannot benefit directly from the fluoridation process; we can benefit indirectly through our children. By approving fluoridation we will not only be relieving them of a great deal of discomfort, but also saving ourselves a great deal of expense—dental service is not free!

Another advantage of this process is its relatively low cost and convenience. Fluoridation can be effected for as little as five to fifteen cents per capita per annum, depending upon the compound used and the amount necessary[21]. It involves neither individual expense, nor inconvenience by way of active public participation.

This example will illustrate the benefits of such a procedure. At the age of seventy a man drinking fluoridated water since birth would have about 67 per cent less tooth decay than a man deprived of fluorine, and would have cost his city only $2.10[21].

The benefits, then, speak for themselves. They are: first, the reduction of tooth decay by two-thirds; second, the protection of future generations; third, the saving of millions of dollars in dental care; and fourth, the possibility of adequate dental care for all, since decay at the present time occurs six times faster than the present quota of dentists can repair it[11].

Despite such favorable findings some misinformed individuals still offer opposition that is detrimental to the cause. The first charge accuses fluoridation of being a "scheme of socialized medicine"—an attempt to take from the American public their civil rights. This, even at first glance, is ridiculous; both the American Medical Association and the American Dental Association have vigorously opposed socialized medicine, and these organizations endorse fluoridation[17] as both safe and effective. Secondly, it could not possibly take

* 1.2 parts fluorine per million parts water (ppm).
** Rate of decayed, missing, and filled teeth (DMF rate).
† Other test cities are Newburg and Kingston, Colorado Springs and Boulder, Colorado.

away civil rights since the proposal to add fluorine must pass through all the democratic processes and be approved by the citizens before any action can be taken. Furthermore, we have been subjected to chlorination for fifty years, and no one has lost any civil rights. Therefore, we cannot consider this objection as logically valid.

Christian Scientists declare that fluoridation is forced medication, and, as such, is contrary to their beliefs. This is not true, for medication is treatment. Fluoridation will neither treat nor cure existing cavities; it merely prevents cavities from getting started[11]. Fluoridation is prevention, not treatment. If the objectors were logical, it would follow from their reasoning that they should buy distilled water to avoid the typhoid prevention afforded by chlorine. They should also bake their own bread and milk their own cows to avoid Vitamin D, the ricket-prevention vitamin which is added to bread and milk commercially.

Some people are concerned about the harm that fluorine might cause to car batteries, radiators, and lawns. This fear can be dismissed once we consider the many, many communities in these United States whose water supplies have a high natural fluorine content and whose car batteries, radiators, and lawns have suffered no harm.

These fears, then, are principally psychological, and are based neither on logical reasoning nor any real danger.

However, there is a more serious question in regard to fluoridation. When the public asks, "It is toxic?", the answer must necessarily be yes; and it is at this point that the greatest public opposition is born.

The fact that fluorine is toxic cannot be denied; but, then, so are many of the substances that we consume daily. The Manufacturing Chemists Association of New York in their booklet *The Use of Chemicals in Foods* states:

> If no food were to be eaten which could have potentially toxic or harmful effects, no matter how abused, a very large part of today's American diet would have to be dropped from the menus[12].

The chlorine we drink in water and the iodine in salt, to mention only two, are toxic substances in large doses. A lethal dose of fluorine is approximately 450 ppm of fluorine in an eight ounce glass of water; and this would be impossible even with gross negligence[12], since the optimum amount which assures adequate decay prevention but will cause no harmful physiological effects has been determined at 1.0 ppm[27].

The amount of fluorine to be added to the water supply varies depending upon the temperature, which increases or decreases water consumption, and the amount of natural fluorine in the water. However, the concentration should not be more than 1.0 ppm for absolute safety and greatest effectiveness.

There are two physiological disorders that can be caused by too high a concentration of the fluorine ion. The first is cumulative toxic bone fluorosis, which means simply an accumulation of fluorine in the bones causing bone fragility. However, a study of four thousand high school boys and army selectees, who had for some time consumed water containing two to five parts per million fluorine, showed not one case of bone fragility caused by fluoride. Furthermore, a town in Texas whose water supply has a natural fluorine content of 18 ppm produced not one proved case of chronic fluoride poisoning[11]. When small amounts of fluorine are taken into the body, a balance is established between consumption, storage, and excretion. In other words, the kidneys take care of the excretion of up to 90 per cent of the ingested fluoride[8] thus reducing the possibility of bone fluorosis when the fluorine content is far higher than 1 ppm.

The second physiological disorder that can occur from too high a concentration of fluorine is mottling of the teeth. This condition is characterized by lesions of the dental enamel, appearing as dark spots on the surface of the teeth. However, this condition attacks the teeth only during the period of calcification and occurs only when the concentration of fluorine is far higher than that recommended by the Public Health Department.

Knutson, in his article *The Case for Water Fluoridation* quotes from the report of the ad hoc Committee on Fluoridation of Water Supplies:

> The margin between the optimal quantity of fluoride in drinking water which is required for maximal benefit in tooth development, and the amount which produces undesirable physiological effects is sufficiently wide to cause no concern.

It is plain that we can be reasonably well assured as to the safety of the proposed fluoridation program.

In the face of the present evidence, would it be advisable for every public health department to provide a fluoridation program for the prevention of tooth decay? Public health is "the science and art of preventing disease, prolonging life, and promoting health and efficiency through organized community effort." These characteristics *can* be applied to the proposed fluoridation program, for a cavity is a disease of the tooth, and fluorine is a preventive. Furthermore, fluoridation, as advised, is inexpensive and has no known objectionable features. It is an excellent public health measure; and as soon as the public accepts these facts, the health department will be ready and willing to initiate a fluoridation program which will benefit us, our children, and our children's children for generations to come. ●

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(Continued on Page 111)

NEW BOOKS

The Zoo Comes to You

• *By* CAPTAIN BURR W. LEYSON AND RUTH MANECKE. New York: E. P. Dutton & Co., Inc., 1954. Pp. 88. $2.95.

A book for the elementary science teacher. Boys and girls in the early grades will be intrigued by its stories and fascinated by its beautifully clear black and white photographs that bring the zoo into the schoolroom or the home. Its 21 stories about animals are simple in text and exceedingly well written. Little Tank the box turtle, Bambi the baby deer, Petunia the skunk, Winky the baby llama, Sleepy the hamster, Blacky the crow, and many more inhabitants of the zoo will become the dear friends of young readers and listeners.

A valuable addition to nature literature in a field in which good teaching aids are needed.

H. C. M.

Spadework

• *By* SIR LEONARD WOOLLEY. New York: Philosophical Library. 1953. Pp. 124. $4.75.

The current wide interest in recently discovered anicent Egyptian tombs makes the appearance of these reminiscences of an eminent British archaeologist especially welcome. Sir Leonard Woolley spent nearly 50 years in archaeological explorations in England, Nubia, South Italy, the Euphrates valley, Mesopotamia, and Turkey. His delightfully written and highly personal account of his experiences demonstrates how much patience, perseverance, knowledge, skill, intelligence and tact are needed for the work. The book is beautifully illustrated. Readers of this scientist's story will gain a much clearer idea of the work of an archaeologist in studying prehistoric cultures, its problems and its rewards. Most readers will be interested enough to finish the book at one sitting.

H. C. M.

Inorganic Quantitative Analysis

• *By* CARROLL WARDLAW GRIFFIN. New York: The Blakiston Company, Inc. 1954. Pp. XVI + 417. $4.75.

This book is recommended for use in a basic course in quantitative analysis. Designed primarily for a full year, it can be adapted to a one-semester course by a proper selection of material. The opening chapters cover fundamentals. Then comes a special chapter dealing with techniques for the isolation of desired constituents by physical and chemical means. In it such techniques as chromatography and ion-exchange are discussed. Subsequent chapters deal with volumetric analysis, oxidation and reduction, gravimetric analysis and volumetric precipitations. In the concluding chapters potentiometric titrations, photometry, and spectrophotometry are considered.

Dr. Griffin does a splendid job in developing the essentials of quantitative analysis. The selection of laboratory exercises is excellent. Numerous problems with answers accompany each chapter. A few of them are simple, as perhaps they should be, but the larger number require thought and resourcefulness on the part of the student. The book appears to be remarkably free of typographical errors. The nickel-dimethylglyoxime complex on page 309 needs revision.

Martin Blake, Ph.D.
Duquesne University

Time Counts: The Story of the Calendar

• *By* HAROLD WATKINS. New York: Philosophical Library. 1954. Pp. X + 274. $4.75.

Insistence on calendar reform increases. A movement, strong in Britain, would effect a change as soon as 1956, surely a dim prospect. A new world calendar may be highly desirable, but widespread interest in it is difficult to arouse. Pope Gregory's calendar of 1582 has long been criticized for defects that might well be corrected. It does not meet completely modern social and business needs. Time, money, and energy might be saved through its reformation.

Our months are irregular in length. Our quarter-years and half-years do not contain identical numbers of days. A year, a month, or a quarter may begin on any one of the seven days of the week. There is no correspondence between days and dates from month to month or year to year. We have leap years, but a one-day adjustment will have to be made in the year 5905! The author points out other irregularities in his well written study of calendar history, giving arguments impartially for and against the proposed changes. This book contains much worth while information. It should be available to browsers in the library.

H. C. M.

Space Travel

• *By* KENNETH W. GATLAND AND ANTHONY M. KUNESCH. New York: Philosophical Library. 1953. Pp. X + 205. $4.75.

A serious book that will be read avidly by adventurers of all ages who seek late authentic information about space flight. Readers will find that the truth is even stranger than fiction. Written by two technical experts, the story begins with the invention of gunpowder and

(Continued on Page 108)

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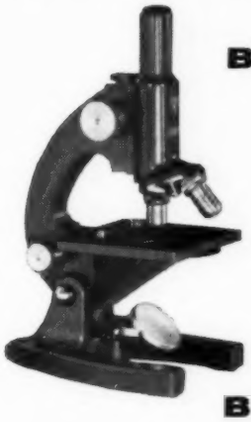

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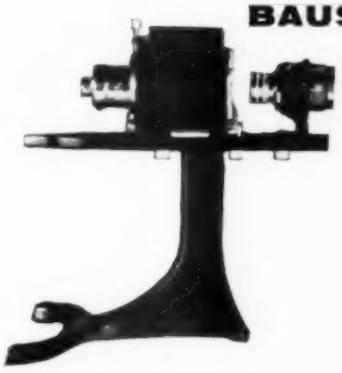

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New Books

(Continued from Page 106)

continues through the flight of the first rocket in Cologne in 1258. Increasing enthusiasm led to the development of live-animal carrying rockets in France in 1830. Modern research resulted in the manufacture of large rockets for military purposes, and the use of new propellants in Germany and the United States. Considerable attention is given to the work of the American pioneer, Robert H. Goddard.

The prospect for space travel for man and its difficulties, such as high accelerations, cabin air conditioning, cosmic rays, temperature control, space suits, and meteors are discussed. It is possible that rockets may be used to build up a store of propellant for refueling interplanetary vehicles on an artifical satellite that will move freely in a circular orbit outside the earth's atmosphere. There are 70 half-tone illustrations, drawings and graphs.

H. C. M.

Free and Inexpensive Learning Materials

• *By* DIVISION OF SURVEYS AND FIELD SERVICES, George Peabody College for Teachers Sixth Edition. Nashville, Tenn. George Peabody College for Teachers. 1954. Pp. VIII + 216. $1.00.

This inexpensive, paper-bound descriptive list is designed to help the student, the teacher, and the librarian gather current sources of information, scientific and otherwise, for schoolroom use. We recommend the purchase of this valuable source book as enthusiastically as we have recommended the earlier editions. The book tells definitely where valuable teaching aids, such as posters, publications, sample materials, exhibits, may be obtained at little or no expense. Its 3246 items, 725 more than were found in the preceding edition, are cataloged under more than 300 separate headings. Almost half of them are new. Only a few cost more than 50 cents. Each item listed has been critically examined by graduate students at the George Peabody College for Teachers. Their evaluations of posters and pamphlets add to the value of the list. Teachers in all departments will consult this book frequently if it is made available to them.

H. C. M.

Organic Chemistry: A Brief Course

• *By* ROBERT WARD GETCHELL. New York: McGraw-Hill Book Company, Inc. 1954. Pp. VIII + 278. $4.00.

This book attempts a difficult task and succeeds admirably. It aims to give certain groups of students a basic knowledge of organic chemistry in one semester or one quarter. The information it supplies is necessarily elementary, but broad in scope. Theoretical aspects are sacrificed for practical applications. Special treatment is given to vitamins, hormones, medicinals, plastics and synthetic fibers. The author writes well. The book is easy to read and easy to understand. It should give the student a desire to study the subject further.

Aliphatics and aromatics are integrated throughout the book. The integration is somewhat lacking in uniformity, and the value of the procedure in this particular kind of book may be questioned. Majors in home economics, nursing, agriculture and a few other fields where organic chemistry is a minor tool will find this book very useful.

Martin Blake

Climate, Vegetation and Man

• *By* LEONARD HADLOW. New York: Philosophical Library. 1953. Pp. 288. $4.75.

This book deals with significant influences of climate on plant, animal, and human life. Man's physical, mental, and spiritual development, as well as his material welfare, depend in great part on the climate in which he makes his home. Changing climatic conditions have influenced the lives of whole peoples.

The first of the three sections of this book deals with climate, the seasons, temperature, atmospheric pressure, winds, rainfall and ocean currents. Section two studies natural vegetation in relation to climactic conditions. In the final section the effect of climate on man's activities is considered.

Good for supplementary reading in high school and for reference. There are many attractive out-of-the-ordinary illustrations, maps and charts. A six-page Index is a valuable part of the book.

H. C. M.

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Future Scientists of America

(Continued from Page 90)

5. *Let's Help America's Science Teachers Find Science-Related Summer Jobs in Industry:* Copies of this brochure were distributed to thousands of industrial management and personnel officials.
6. *Encouraging Future Scientists: Materials and Services Available in 1954-55:* Bibliographical listing of incentive, guidance, and specialized training services that are available to science teachers and their students.
7. *Encouraging Future Scientists: Student Projects:* Eighteen types of projects that have been entered in the Awards Program. Suggests new projects and how they can be reported.
8. *Selected Science Teaching Ideas:* Abstracts and summaries of entries in the Science Teacher Recognition Awards Program.
9. *Careers in Science Teaching:* This pamphlet can be used to interest capable young people in the profession.

All science teachers are invited not only to take part in the Foundation's program but also to suggest ways and means of making the program more effective. •

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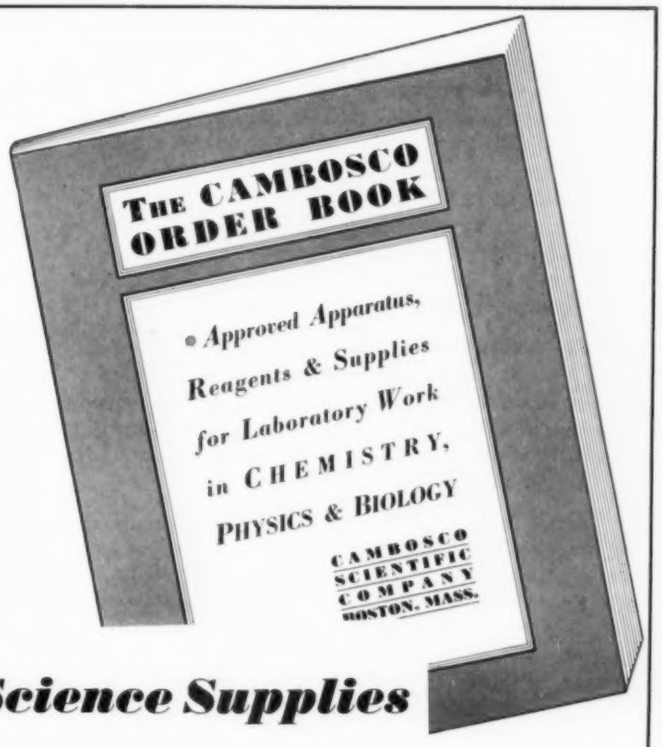
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An American Alchemist

(Continued from Page 99)

Alchemy—so Paracelsus and Boehme taught—could transmute pure gold out of base materials only if the alchemist himself were pure. Hildegarde Mutschler's very presence made the work impossible. "The heavenly wave of light could not come near," Frederick wrote. "As soon as I realized this, I did not wish to have anything to do with the Work . . . although it was a practice I always favored most. I must, therefore, abandon my hopes."

Clearly, Frederick had also been trying to open the "Twelve Gates" of the alchemists in the laboratory behind the Great House. Nor did he abandon his hopes, for he and Dr. Müller must soon have begun to train the new assistants whose touch would not profane Father Rapp's "Great Work."

But George Rapp's own hopes soon began to crumble. There was the Leon episode, showing him that nearly a third of his people no longer followed his teachings. In 1834 Frederick died; Dr. Müller left soon after. The people of Economy had found earthly gold in abundance through their industry and Frederick's ingenuity and intelligence: George Rapp controlled a $2,000,000 fortune. But the possibility of achieving spiritual perfection through the laboratory must have seemed more and more remote. In August, 1847, nearly 90, the big old man with the white beard looked his last on Economy, and America was done with alchemy. ●

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Furthermore, our lives are affected today by science in more than a purely material sense. Science endows us with an understanding of the world around us that affords a delight to the mind, showing the interaction of the data of common experience, the enlarged vision obtained through the use of scientific instruments, the application of logic and the creative imagination. Science not only makes possible control of our environment, but enables us to predict, and thus be prepared for, events that we cannot control, such as storms and astronomical phenomena. A recognition of the cyclic repetition of natural events, and the causal explanation of them, removes the terrors that had previously accompanied the appearance of comets, eclipses, and even plagues. Only a few years ago, a comet was the occasion of apprehension, but today we may peacefully admire its appearance.

—I. Bernard Cohen
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Fluoridation for Health

(Continued from Page 105)

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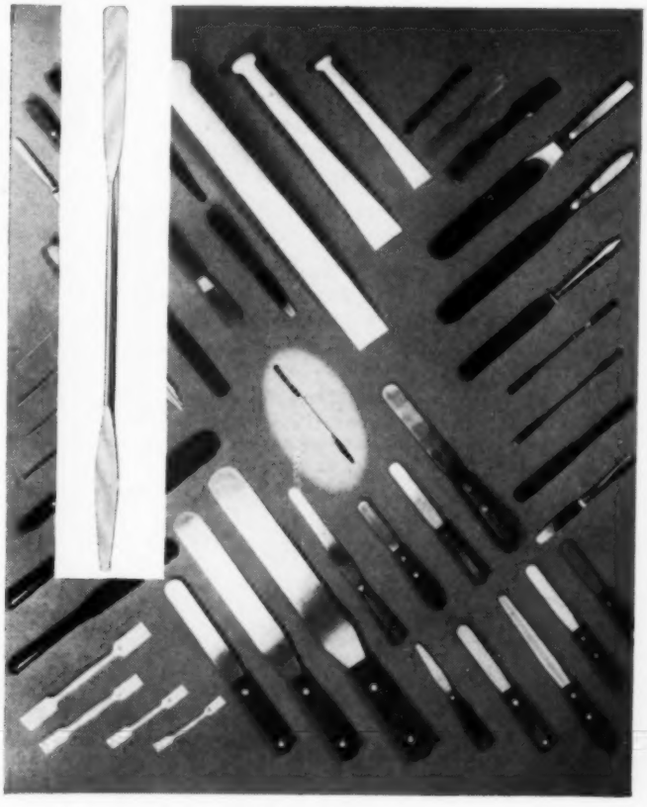

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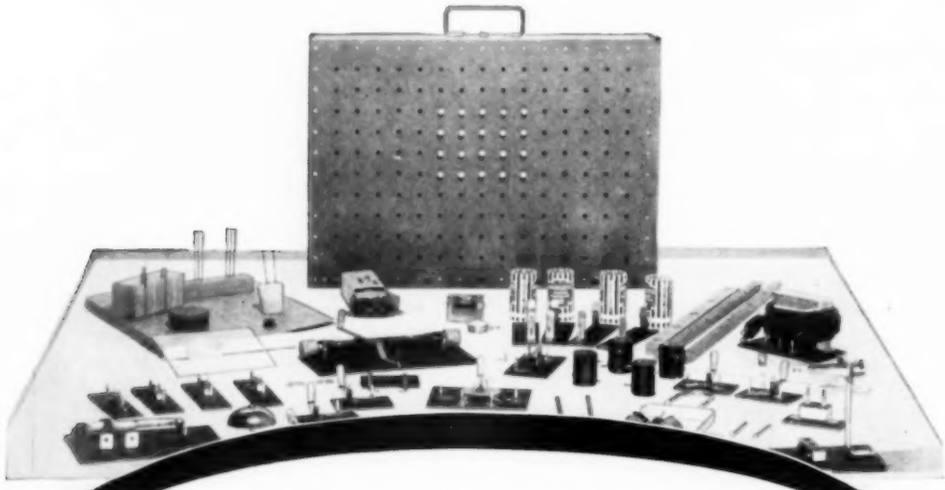

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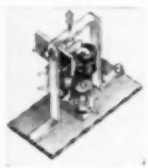

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(Continued from Page 96)

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Water

(Continued from Page 87)

itself is either not a balanced food for oysters, or is not eaten, or produces substances termed external metabolites, which interfere with the normal life processes of the oysters. They fail to grow and to fatten and either die or are so poor in quality that they cannot be harvested. As a result, all those remaining have been shipped to the cleaner Gardiner and Peconic Bays, and an industry worth $1,500,000 yearly has ceased to exist. Other damages have resulted also. Today the situation is under study and plans are being formulated to abate the pollution and allow the two important food producing industries to exist side by side. But because there was no evident nuisance production (odors, bad water) or health menace (typhoid fever), it took almost 20 years for this type of pollution to become generally recognized and studied for a cure.

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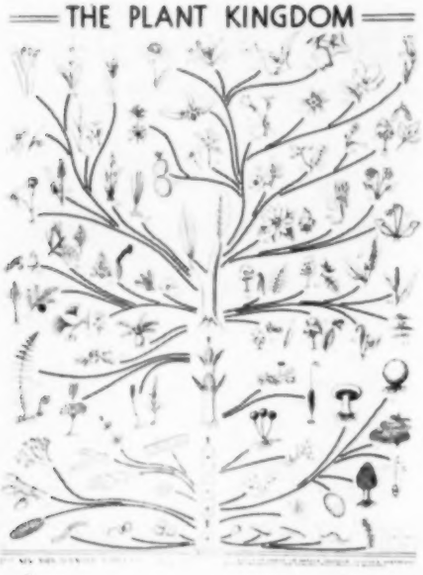

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Another factor in lowering the ground-water table has been the excessive drainage of swamps and lakes. This has represented a misuse of natural water, in that it has robbed waterfowl and other game of badly needed breeding areas and protection. This in turn has affected recreation. But the real danger has been the fall of the ground-water level.

This subject of the use and misuse of water is capable of endless discussion. Water alone is enough to determine whether or not man inhabits an area. But we have pointed out that whatever man does to water changes it, and that thus far too many of these changes have been bad. It is worth remembering by all of us that whenever we have a chance through legislation or by public expression, we should safeguard this priceless heritage—water, good water. ●

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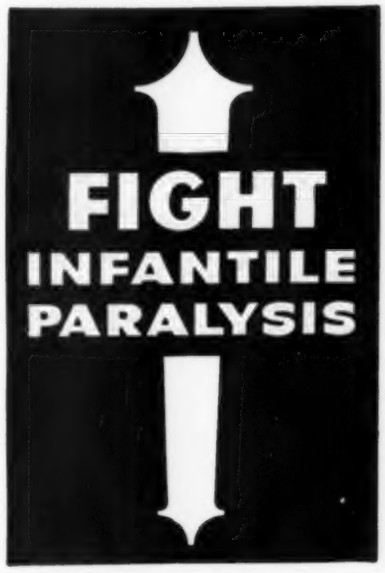

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Approach to Zoology

(Continued from Page 101)

demonstrate the "why" of the morphology through the "how" of function are without number.

In addition to the gratifying entirety of the biological picture achieved through the functional approach it should be noted that the mental discipline resulting from such an approach is considerably greater than that resultant from the conventional factual avenue. An ability to critically analyze, to see the basic concept, to select the relevant from the non-relevant detail and to extrapolate to general principles governing biological activity are more likely to be the reward of biological studies when approached from the dynamic conceptual aspect that when viewed and studied from the descriptive aspect.

It is these things which we have not seen in too many of the students of the biological sciences and it may well be that with the placement of the same emphasis on physiology that is given to morphology, biology will attract better students and that formal training in this science will provide a more united and meaningful whole than it has in the past. ●

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The Bell Solar Battery

(Continued from Page 84)

To apply this knowledge to devices, the first successful step was the growing of silicon single crystals. The second step of adequately purifying silicon proved very difficult, since it is chemically much more active than germanium. Careful fractionation, including distillation of silicon derivatives, finally led to unexcelled purity of the element.

The chemical technique basic to the operation of the solar battery was developed by C. S. Fuller, and has been successfully used in a variety of silicon devices. It consists of the preparation of p-n junctions by diffusing impurities into the surface of a silicon wafer. Using such "diffusion junctions," Pearson has made successful high-power rectifiers and lightning arrestors. To make the large-area solar batteries, D. M. Chapin has developed the techniques pioneered by Fuller and Pearson.

Diffusion techniques show great promise of being widely applicable to many kinds of semiconductor devices made from both germanium and silicon. The process developed by Fuller consists simply of heating the semi-conductor wafer in the presence of a suitable impurity vapor. In this way, p- or n-type layers of controlled thickness are formed just below the semiconductor surface. The method may be used for either large-area, high-power devices or for devices with more complicated geometries where exceedingly small dimensions are required. The ultimate potentialities of this diffusion procedure are still being explored. The teamwork developments in crystal purity and perfection combined with a knowledge of ways to maintain extreme surface cleanliness have meanwhile removed many of the obstacles which formerly existed. ●

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It is a common experience of all science teachers that the most recent discoveries in science offer the greatest fascination for the majority of students, in adult education as well as colleges. Unfortunately, the presentation of the exciting frontiers of scientific knowledge requires of the student a mastery of considerable previous information; it is not possible to build a physics course on radio-activity, relativity, quantum theory and nuclear physics. The question is, therefore, whether we can arouse from older or classical topics the same kind of exciting response as from the science of the present or very recent past. I believe that we can attain such goals to a limited degree, although it would be absurd to suppose that the theory of the inclined plane can ever again be made as exciting as relativity.

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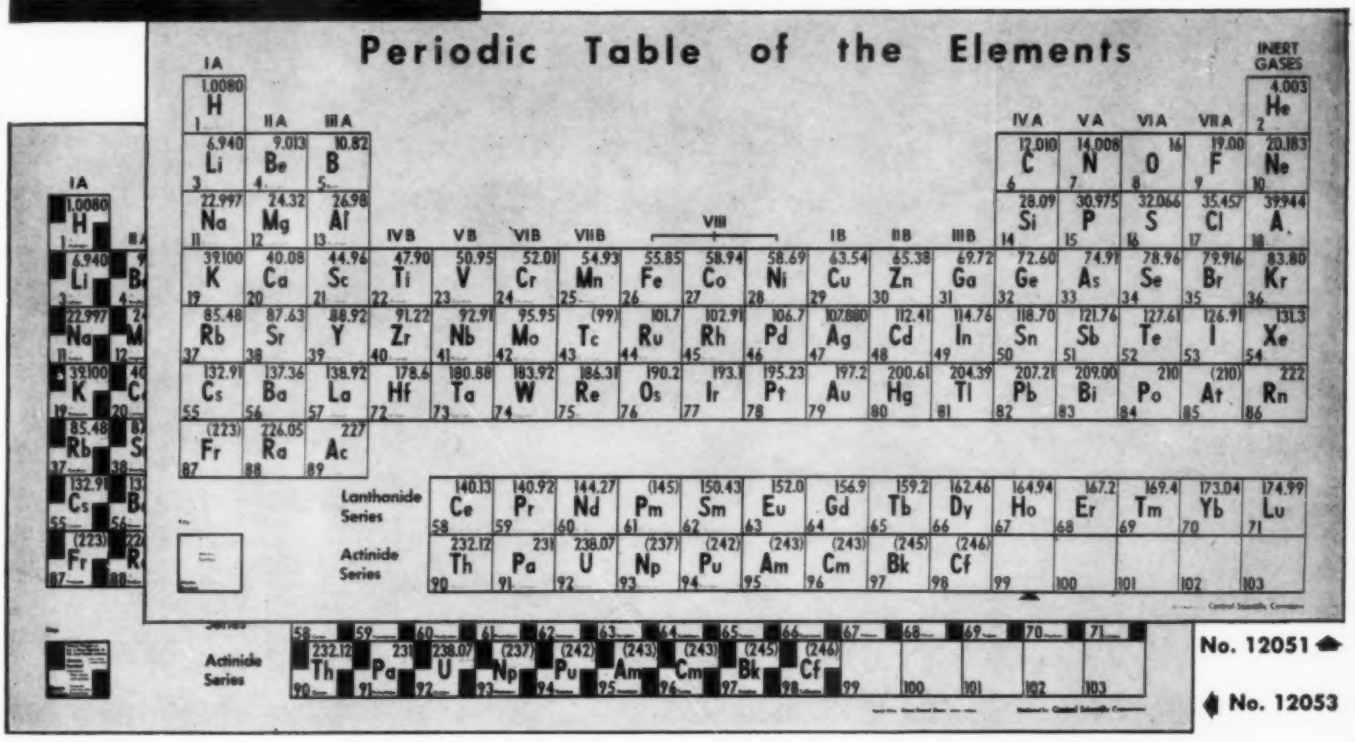

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